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PICKERING NGS 'A' UNIT 2
CALANDRIA DUMP AND CIV CLOSURE TESTS - MODERATOR PUMPSET/PIPING VIBRATION RESULTS

Report No 88-284-K

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ABSTRACT

Three tests involving calandria dump and calandria inlet valve closure were performed in July 1988 during which the vibration response of the moderator pumpsets and piping was measured. High overall motor casing velocity and pump shaft displacement levels were measured on all operating pumpsets during the three tests. It is likely that the pump bushings were rubbed during periods of the tests. Based on the high vibration levels measured during the tests, there is no guarantee that the moderator pumpsets will perform satisfactorily should they be subjected to similarly high vibration levels in the future.

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EXECUTIVE SUMMARY

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Mechanical Research Department

Three tests involving calandria dump and calandria inlet valve closure were carried out in July 1988 during which the vibration response of the moderator pumpsets and piping was measured.

High overall motor casing velocity and pump shaft displacement levels were measured on all four operating pumpsets (Pumpsets P1, P2, P3 and P5) during the three tests. It is likely that the pump bushings were rubbed during periods of the tests.

Unless cumulative fatigue damage to the various pumpset components can be determined, then based on the high vibration levels measured during the tests, there is no guarantee that the moderator pumpsets will perform satisfactorily should they be subjected to similarly high vibration levels in the future.

It is recommended that the pumpsets be inspected for mechanical damage. This inspection would give an indication of the possible damage to the pumpset components (eg, pump bushing, seal) due to the high vibration levels. The high pump shaft displacements measured on pumpsets P2, P3 and P5 during normal steady state operation should be investigated. Balancing of these pumpsets may be required.

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740627-019-052	825.4	September 1, 1989	88-284-K

TABLE OF CONTENTS

Page

1.0 INTRODUCTION 1

2.0 DESCRIPTION OF CALANDRIA DUMP AND CIV CLOSURE TESTS 1

3.0 TEST METHOD, INSTRUMENTATION AND MEASUREMENTS 2

- 3.1 Test Method 2
- 3.2 Instrumentation 2
- 3.3 Measurements 2
  - 3.3.1 Motor Casing Overall Velocity Levels 2
  - 3.3.2 Pump Shaft Overall Displacement Levels 2
  - 3.3.3 Piping Overall Vibration Levels 3
  - 3.3.4 Velocity and Displacement Spectra 3
  - 3.3.5 Structural Natural Frequencies 3
  - 3.3.6 Process Conditions 3
  - 3.3.7 Time Plots of Overall Vibration Levels 3
- 3.4 Vibration Limits 4

4.0 RESULTS 4

- 4.1 Baseline Vibration Levels 4
- 4.2 Test No 1 - Moderator Dump Test 5
  - 4.2.1 Pumpset Overall Vibration Levels and Vibration Spectra 5
  - 4.2.2 Piping Overall Vibration and Velocity Spectra 5
- 4.3 Test No 2 6
  - 4.3.1 Moderator Dump Test 6
    - 4.3.1.1 Pumpset Overall Vibration Levels and Vibration Spectra 6
    - 4.3.1.2 Piping Overall Vibration and Velocity Spectra 6
  - 4.3.2 CIV Closure Test 7
    - 4.3.2.1 Pumpset Overall Vibration Levels and Vibration Spectra 7
    - 4.3.2.2 Piping Overall Vibration and Velocity Spectra 7
  - 4.3.3 Controller Failure Event 8
    - 4.3.3.1 Pumpset Overall Vibration Levels and Vibration Spectra 8
    - 4.3.3.2 Piping Overall Vibration and Velocity Spectra 8

4.4 Test No 3 8
4.4.1 Moderator Dump Test 8
4.4.1.1 Pumpset Overall Vibration Levels and Vibration Spectra 8
4.4.1.2 Piping Overall Vibration and Velocity Spectra 9

4.4.2 CIV Closure Test 9
4.4.2.1 Pumpset Overall Vibration Levels and Vibration Spectra 9
4.4.2.2 Piping Overall Vibration and Velocity Spectra 10

5.0 VIBRATION LEVELS VERSUS AVAILABLE NPSH 10

6.0 ASSESSMENT OF VIBRATION LEVELS 10

7.0 MEASURING SHAFT RUNOUT 11

8.0 POSSIBLE MODES OF FAILURE 12

9.0 METHODS USED TO DETERMINE PUMPSET HEALTH 12

10.0 CONCLUSIONS 13

11.0 RECOMMENDATIONS 13

REFERENCES 15

TABLES

FIGURES

APPENDIX A - Calandria Dump and CIV Closure Tests - Plots of Process Conditions

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To Mr. J.A. Blasko
Pickering Engineering

PICKERING NGS 'A' UNIT 2
CALANDRIA DUMP AND CIV CLOSURE TESTS - MODERATOR PUMPSET/PIPING VIBRATION RESULTS

1.0 INTRODUCTION

As requested by Pickering Engineering, Mechanical Research performed vibration measurements during three calandria dump/CIV closure tests performed in July 1988. The objective of these tests was to determine the system response during calandria dump and calandria inlet valve (CIV) closure. Vibration measurements were made on the Unit 2 moderator pumpsets and on the adjoining piping system.

This report summarizes the vibration data obtained during the three tests carried out on July 4, July 18 and July 19, 1988.

2.0 DESCRIPTION OF CALANDRIA DUMP AND CIV CLOSURE TESTS

In total, four tests were carried out to obtain the transient response of the moderator system during moderator dump and CIV closure. A brief description of the tests follows. A detailed description is given in Reference 1.

Test No 1 (4 July 1988)

This test consisted of a moderator dump only and was carried out at a system temperature of 67°C. The calandria outlet valves (COVs) were limited to a maximum closure of 85% /1/.

Test No 2 (18 July 1988)

This test consisted of a moderator dump followed by closure of the CIV approximately 5 minutes later. The system temperature was 65°C and the COVs were limited to a maximum closing of 85%. The calandria rupture disc leaked during this test. In addition, the COV controller malfunctioned during the test. /1/

Test No 3 (19 July 1988)

Test No 3 consisted of a moderator dump followed by closure of the CIV. The defective controller (Test No 2) was replaced prior to this test. However, the leaking calandria rupture discs were not replaced. This test was conducted at a system temperature of 63°C. The COVs were limited to a maximum closing of 85% /1/.

Test No 4 (2 August 1988)

Test No 4 consisted of a moderator dump and CIV closure. The leaking calandria rupture discs were replaced prior to this test. The system temperature was 63°C, and the COVs were limited to a maximum closing of 80% /1/. No vibration measurements were taken during this test.

3.0 TEST METHOD, INSTRUMENTATION AND MEASUREMENTS

3.1 Test Method

The general pumpset arrangement, measurement locations and directions as well as the identifications used in this report are shown in Figures 2 and 3.

The moderator pumpsets' shaft displacement and motor casing velocity levels, as well as the piping velocity and displacement levels were continuously monitored throughout the tests. Only four of the five moderator pumpsets were run during the tests, namely Pumpsets P1, P2, P3 and P5 (1-3 configuration). Pumpset P4 was not run.

3.2 Instrumentation

The main components of the instrumentation used in obtaining the measurements are listed in Table 1 and are further discussed in Section 3.3. Figure 1 shows the instrumentation layout. All vibration signals were recorded on magnetic tape and later analyzed.

3.3 Measurements

3.3.1 Motor Casing Overall Velocity Levels

The overall velocity levels were determined from accelerometer (Bruel & Kjaer Model 4384) signals which were integrated to velocity and then recorded on a visicorder. All velocity levels are presented in mm/s peak. Vibration amplitude versus time plots were also produced with a visicorder.

The motor casing velocity measurements were obtained at the top of the motor in the East-West and North-South directions (Figures 2 and 3).

3.3.2 Pump Shaft Overall Displacement Levels

Overall displacement levels of the pump shaft were determined from displacement transducer (Bently Nevada 7200 series, 5 mm) signals analyzed using a Honeywell 1858 Visicorder.

New non-contact displacement transducers were installed on Pumpsets No 1, 2, 4 and 5. These transducers were placed orthogonally, in the East-West and North-South directions, at the location shown in Figure 2. An existing non-contact displacement transducer on Pumpset No 3 was calibrated in situ and was used for the shaft displacement measurements.

3.3.3 Piping Overall Vibration Levels

The piping overall velocity and displacement levels were determined from accelerometer (Bruel & Kjaer Model 4370) signals which were integrated (once for velocity and twice for displacement) and analyzed using a Honeywell 1858 Visicorder.

The accelerometers used to measure the piping vibration were installed close to the pipe expansion joints EJ-3 and EJ-4, in the horizontal, vertical and axial directions, as shown in Figure 3.

3.3.4 Velocity and Displacement Spectra

Velocity and displacement spectra were generated by analyzing the vibration signals with an Ono Sokki CF920 dual channel Fast Fourier Transform (FFT) analyzer. Hard copies of the spectra were obtained with a digital plotter (Hewlett Packard 7470A).

Each spectrum shown in this report is the sum average of sixteen instantaneous spectra.

3.3.5 Structural Natural Frequencies

Impact tests to determine moderator pumpset-piping structural natural frequencies were previously performed and the results reported in September 1974/2/. The first two system natural frequencies were determined to be at 6 Hz and 10 Hz. Additional structural natural frequencies at 15 Hz, 22 Hz, 33 Hz, 40 Hz, 44 Hz and 54 Hz were also apparent.

3.3.6 Process Conditions

Various process conditions measured during the tests are reported in detail in reference /1/. Plots of some of the process conditions measured during Tests 1, 2 and 3 are provided in Appendix A.

3.3.7 Time Plots of Overall Vibration Levels

Plots of overall vibration level versus time were produced for each test. Major events which occurred during the tests (eg, dump, CIV closure,COV throttling, etc) are indicated along the time axis. Shutdown of pumpset P3 signifies the end of each test. In all three tests, pumpset P3 was the first of the four operating pumps to be switched off.

Each time plot generally shows the overall vibration levels from the start of the dump to a short time after pumpset P3 is shutdown. In some instances, the time plots begin after the dump has started. In such cases, it should be noted that the overall vibration levels from the beginning of the dump to the first plotted levels were constant. The ordinate of each vibration plot has its own scale.

3.4 Vibration Limits

Prior to the tests, vibration limits for the moderator pumpsets and piping were established by the various groups involved. These limits, listed below, were outlined in Reference /3/. Both a steady state limit and a "5 second to 10 second" limit are given. A measured vibration level exceeding the "5 second to 10 second" limit for a sustained period of 5 seconds was to be given immediate attention, with a decision to abort the test being made within the next five seconds.

Measurement	Steady State Limit	"5 sec - 10 sec" Limit
Pump Shaft Displacement	100 μm p-p	130 μm p-p
Motor Casing Velocity	18 mm/s pk	40 mm/s pk
Discharge Piping Velocity	40 mm/s pk	175 mm/s pk
Expansion Joint EJ-3 Displacement	12 mm p-p	25 mm p-p
Expansion Joint EJ-4 Displacement	6 mm p-p	12 mm p-p

4.0 RESULTS

4.1 Baseline Vibration Levels

Prior to the dump/CIV closure tests, vibration levels were measured on four pumpsets (P1, P2, P3 and P5 - 1-3 configuration) operating under normal steady state conditions. These baseline levels of the motor casing velocities and pump shaft displacements are summarized in Tables 2 and 3.

The maximum overall pump shaft displacements (Table 3) range from 100 μm p-p (Pumpset P1) to 215 μm p-p (Pumpset P3), and are considered high. The filtered 1 x RPM (30 Hz) shaft displacement levels are 59 μm p-p for Pumpset P1, 135 μm p-p for Pumpsets P2 and P5, and 185 μm p-p for Pumpset P3. The relatively high 1 x RPM displacements measured on pumpsets P2, P3 and P5 are most likely due to unbalance. It is recommended that, at the earliest opportunity, a detailed investigation be carried out to determine the cause of these high levels. Balancing of the pumpsets may be required.

The overall velocity levels measured on the motor casings (Table 2), range from 8 mm/s (Pumpset P1, N-S direction) to 12 mm/s (Pumpset P3). Since the motors are relatively softly supported, these levels, although high, are not considered unacceptable. The filtered 1 x RPM velocity levels range from 1.2 mm/s (Pumpset P2, E-W direction) to 4 mm/s (Pumpset P5, E-W direction).

Velocity spectra obtained on the motor casings (Figures 22 - 29) show that the predominant vibration is generally at 1 x RPM frequency (30 Hz) and at several frequencies below 20 Hz. These low frequency components below 20 Hz are most likely due to flow excitation of the various pumpset/piping structural natural frequencies. Pump shaft displacement spectra (Figures 30 - 36) show that the main vibration component is at 1 x RPM frequency.

4.2 Test No 1 - Moderator Dump Test

4.2.1 Pumpset Overall Vibration Levels and Vibration Spectra

Motor casing velocity levels and pump shaft displacement levels versus time plots are shown in Figures 4, 5 and 6. Tables 4 and 5 show the amount of time that the overall vibration level exceeds a specified level. The total time frame considered was from the beginning of the dump to shutdown of pumpset P3 (ie, the duration of the dump test) and was 157 seconds.

Table 4 shows that the maximum casing velocities, measured on the operating pumpset motors during the moderator dump test, range from 55 mm/s to 100 mm/s, depending on the pumpset. The velocity levels exceed 20 mm/s for approximately 80 to 125 seconds, and they exceed 50 mm/s for about 1 to 12 seconds.

The maximum pump shaft overall displacement levels, measured on the operating pumpsets during the test (Table 5), range from 330 μm p-p to 480 μm p-p, depending on the pumpset. The displacement levels exceed 150 μm p-p for approximately 140 to 157 seconds, and they exceed 300 μm p-p for about 10 to 35 seconds.

Velocity spectra were obtained at two stages during the test where relatively high transient vibration was measured. The first is just after the COVs began to throttle (Location 1), and the second approximately 20 seconds before P3 was shutdown (Location 2). These two 'locations' are indicated in the time plots by an asterisk (*). Velocity spectra obtained on the motors during the test are shown in Figures 37 to 44 for 'Location 1', and in Figures 59 to 66 for 'Location 2'. These spectra show main vibration components below 10 Hz which correspond to the system structural natural frequencies, at the pumpset operating frequency (30 Hz approximately), and at the vane-pass frequency of 149 Hz (5 x operating speed).

Pump shaft displacement spectra obtained on the operating pumpsets during the test (Figures 45 to 52 for 'Location 1'; Figures 67 - 74 for 'Location 2') show that the main vibration components are generally at 30 Hz (operating speed) and 150 Hz (vane pass frequency).

4.2.2 Piping Overall Vibration Levels and Velocity Spectra

The velocity and displacement levels, measured on the moderator piping close to the expansion joints (EJ-3 and EJ-4, Figure 3), versus time plots are shown in Figures 7 and 8.

The maximum overall velocity levels (Table 6) measured on the piping close to EJ3 range from 60 mm/s to 65 mm/s, depending on the measurement direction. For the EJ4 piping, the levels range from 70 mm/s to 120 mm/s. The piping velocity levels exceed 40 mm/s for approximately 6 seconds close to EJ3, and for approximately 24 seconds close to EJ4.

The maximum overall piping displacements measured close to EJ3 range from 1.3 mm p-p to 1.6 mm p-p, depending on measurement direction. For EJ4 piping, the maximum displacements range from 1 mm p-p to 3.8 mm p-p (Table 6).

Velocity spectra obtained on the moderator piping at the two stages (Section 4.2.1) during the test are shown in Figures 53 to 58 and Figures 75 to 80. These spectra show that the predominant vibration is generally at several frequencies below 20 Hz, at 30 Hz and at the vane pass frequency (149 Hz). These low frequency components below 20 Hz are most likely due to flow excitation of the various pumpset/piping structural natural frequencies.

4.3 Test No 2

4.3.1 Moderator Dump Test

4.3.1.1 Pumpset Overall Vibration Levels and Vibration Spectra

Motor casing velocity levels and pump shaft displacement levels versus time plots are shown in Figures 9, 10 and 11. Tables 7 and 8 show the amount of time that the overall vibration level exceeds a specified level. The total duration of the dump test (considered to be from the beginning of the dump to the CIV closure) was 285 seconds.

The maximum casing velocities, measured on the operating pumpset motors during the dump test (Table 7), range from 34 mm/s to 50 mm/s, depending on the pumpset. The velocity levels exceed 20 mm/s for approximately 2 to 7 seconds.

The maximum pump shaft overall displacement levels, measured on the operating pumpsets (Table 8), range from 275 μm p-p to 325 μm p-p, depending on the pumpset. The displacement levels exceed 150 μm p-p for approximately 5 to 285 seconds, and they exceed 200 μm p-p for about 2 to 285 seconds.

Motor casing velocity and shaft displacement spectra were obtained at the first vibration transient during the dump test (as indicated by a '*' in the time plots). The velocity spectra (Figures 81 - 89) show main vibration components below 10 Hz which correspond to the system structural natural frequencies, and at the pumpset operating frequency. The pump shaft displacement spectra obtained on the operating pumpsets (Figures 90 - 97) show that the main vibration component is at 30 Hz.

4.3.1.2 Piping Overall Vibration Levels and Velocity Spectra

The velocity and displacement levels, measured on the moderator piping close to the expansion joints (EJ-3 and EJ-4, Figure 3), versus time plots are shown in Figures 12 and 13.

The maximum overall velocity levels measured on the piping close to EJ3 (Table 9) range from 75 mm/s to 87 mm/s, depending on the measurement direction. For the EJ4 piping, the maximum level is 62 mm/s. The piping velocity levels exceed 40 mm/s for a maximum of 4 seconds.

The maximum piping displacements measured close to EJ3 range from 0.1 mm p-p to 0.2 mm p-p, depending on measurement direction. For EJ4 piping, the maximum displacement is 0.1 mm p-p (Table 9).

Velocity spectra obtained on the moderator piping at the first transient during the dump test are shown in Figures 98 to 102.

4.3.2 CIV Closure Test

4.3.2.1 Pumpset Overall Vibration Levels and Vibration Spectra

Motor casing velocity levels and pump shaft displacement levels versus time plots are shown in Figures 9, 10 and 11. Tables 10 and 11 show the amount of time that the overall vibration level exceeds a specified level. The total duration of the CIV closure test (considered to be from the CIV closure to the controller failure) was approximately 178 seconds. The maximum casing velocity levels and pump shaft displacement levels, measured during the CIV closure test, are also shown in Tables 10 and 11, respectively.

Table 10 shows that the maximum casing velocities, measured on the operating pumpset motors during the CIV closure test, range from 44 mm/s to 112 mm/s, depending on the pumpset. The velocity levels exceed 20 mm/s for approximately 12 to 16 seconds, and they exceed 40 mm/s for about 1 to 8 seconds.

The maximum overall shaft displacement levels, measured on the operating pumpsets (Table 11), range from 240 μm p-p to 327 μm p-p, depending on the pumpset. The displacement levels exceed 150 μm p-p for approximately the duration of the test (178 seconds), and they exceed 200 μm p-p for about 15 to 178 seconds.

Motor casing velocity and shaft displacement spectra were obtained at the first vibration transient after the CIV closure (as indicted by a '*' in the time plots). The velocity spectra (Figures 103 - 107) show main vibration components below 10 Hz which correspond to the system structural natural frequencies. The pump shaft displacement spectra obtained on the operating pumpsets (Figures 112 to 119) show that the main vibration component is at 30 Hz and at the vane pass frequency (149 Hz).

4.3.2.2 Piping Overall Vibration Levels and Velocity Spectra

The velocity and displacement levels, measured on the moderator piping close to the expansion joints (EJ-3 and EJ-4, Figure 3), versus time plots are shown in Figures 12 and 13.

The maximum overall velocity levels measured on the piping close to EJ3 (Table 12) range from 50 mm/s to 75 mm/s, depending on the measurement direction. For the EJ4 piping, the maximum level ranges from 40 mm/s to 75 mm/s. The piping velocity levels exceed 40 mm/s for a maximum of approximately 8 seconds.

The maximum piping displacements measured close to EJ3 range from 0.4 mm p-p to 0.5 mm p-p, depending on measurement direction. For EJ4 piping, the maximum displacement is 0.3 mm p-p (Table 12).

Velocity spectra obtained on the moderator piping at the first transient after the CIV closure are shown in Figures 120 to 124. These spectra show that the predominant vibration is generally at several frequencies below 20 Hz and at the vane pass frequency.

4.3.3 Controller Failure Event

4.3.3.1 Pumpset Overall Vibration Levels and Vibration Spectra

Motor casing velocity levels and pump shaft displacement levels versus time plots are shown in Figures 9, 10 and 11. Tables 13 and 14 show the amount of time that the overall vibration level exceeds a specified level. The total duration this unanticipated event (considered to be from the the controller failure to the shutdown of Pumpset P3) was approximately 12 seconds. The maximum casing velocity levels and pump shaft displacement levels, measured during this 12 second period, are also shown in Tables 12 and 13, respectively.

The time plots of motor casing velocities show a short duration transient following the controller failure.

4.3.3.2 Piping Vibration Levels

Velocity and displacement levels measured on the moderator piping (close to the expansion joints EJ-3 and EJ-4, Figure 3), during the controller failure event, are shown in Figures 12 and 13 as a function of time. However, during this event, the instrumentation amplifiers overloaded. Thus, the piping vibration levels shown on the time plots during this period may not be accurate.

4.4 Test No 3

4.4.1 Moderator Dump Test

4.4.1.1 Pumpset Overall Vibration Levels and Vibration Spectra

Motor casing velocity levels and pump shaft displacement levels versus time plots are shown in Figures 14, 15 and 16. Table 16 shows the amount of time that the overall shaft displacement level exceeds a specified level. The total duration of the dump test (considered to be from the beginning of the dump to the CIV closure) was 180 seconds.

The maximum casing velocities, measured on the operating pumpset motors during the moderator dump test (Table 15), range from 9 mm/s to 12 mm/s, depending on the pumpset.

The maximum pump shaft overall displacement levels, measured on the operating pumpsets (Table 16), range from 125 μm p-p to 240 μm p-p, depending on the pumpset. The displacement levels exceed 150 μm p-p for approximately 180 seconds on Pumpsets P2, P3 and P5, and they exceed 200 μm p-p for 180 seconds on Pumpsets P2 and P3.

Motor casing velocity and shaft displacement spectra were obtained at approximately 40 seconds before the CIV closure (as indicated by a '*' in the time plots). The velocity spectra (Figures 125 - 131) show main vibration components below 10 Hz which correspond to the system structural natural frequencies, and at the pumpset operating frequency. The pump shaft displacement spectra obtained on the operating pumpsets (Figures 132 to 139) show that the main vibration component is at 30 Hz.

4.4.1.2 Piping Overall Vibration Levels and Velocity Spectra

Velocity and displacement levels measured on the moderator piping (close to the expansion joints EJ-3 and EJ-4, Figure 3), during the dump test, are shown in Figures 17 and 18 as a function of time.

The maximum overall velocity levels measured on the piping close to EJ3 (Table 17) range from 15 mm/s to 21 mm/s, depending on the measurement direction. For the EJ4 piping, the maximum level is 15 mm/s. (For the EJ4 piping, a velocity measurement was obtained in the horizontal direction only.)

The maximum piping displacements measured close to EJ3 is less than 0.1 mm p-p. For EJ4 piping, the maximum displacement is less than 0.5 mm p-p (Table 17).

Velocity spectra obtained on the moderator piping during the dump test are shown in Figures 140 to 144.

4.4.2 CIV Closure Test

4.4.2.1 Pumpset Overall Vibration Levels and Vibration Spectra

Motor casing velocity levels and pump shaft displacement levels versus time plots are shown in Figures 15, 16 and 17. Tables 18 and 19 show the amount of time that the overall vibration level exceeds a specified level. The total duration of the CIV closure test (considered to be from the CIV closure to the shutdown of Pumpset P3) was approximately 160 seconds.

Table 18 shows that the maximum casing velocities, measured on the operating pumpset motors during the CIV closure test, range from 35 mm/s to 100 mm/s, depending on the pumpset. The velocity levels exceed 20 mm/s for approximately 40 to 45 seconds, and they exceed 40 mm/s for a maximum of 4 seconds.

Table 19 shows that the maximum overall shaft displacement levels, measured on the operating pumpsets, range from 298 μm p-p to 420 μm p-p, depending on the pumpset. The displacement levels exceed 150 μm p-p for approximately the duration of the test (160 seconds), and they exceed 200 μm p-p for about 55 to 160 seconds.

Motor casing velocity and shaft displacement spectra were obtained at the first vibration transient after the CIV closure (as indicated by a '*' in the time plots). The velocity spectra (Figures 145 - 151) generally show main vibration components below 10 Hz which correspond to the system structural natural frequencies. The pump shaft displacement spectra obtained on the operating pumpsets (Figures 152 to 159) show that the main vibration component is at 30 Hz and at the vane pass frequency (149 Hz).

4.4.2.2 Piping Overall Vibration Levels and Velocity Spectra

The velocity and displacement levels, measured on the moderator piping close to the expansion joints (EJ-3 and EJ-4, Figure 3), versus time plots are shown in Figures 17 and 18.

The maximum overall velocity levels measured on the piping close to EJ3 (Table 20) range from 82 mm/s to 170 mm/s, depending on the measurement direction. For the EJ4 piping, the maximum level is 90 mm/s. (For the EJ4 piping, a velocity measurement was obtained in the horizontal direction only.) The EJ3 piping velocity levels exceed 80 mm/s for approximately 2 to 30 seconds. The EJ4 piping velocity level exceeds 80 mm/s for approximately 20 seconds.

The maximum piping displacements measured close to EJ3 range from 0.5 mm p-p to 5.5 mm p-p, depending on the measurement location. For EJ4 piping, the maximum displacements range from 2.6 mm p-p to 6.0 mm p-p (Table 20).

Velocity spectra obtained on the moderator piping at the first transient after the CIV closure are shown in Figures 160 to 164. These spectra show that the predominant vibration is generally at several frequencies below 20 Hz and at the vane pass frequency.

5.0 VIBRATION LEVELS VERSUS AVAILABLE NPSH

The available net positive suction head (NPSH) and pumpset vibration levels during the three tests are shown in Figure 19 (Test No 1), Figure 20 (Test No 2), and Figure 21 (Test No 3). For all three tests, the pumpsets' vibration levels increase when there is insufficient NPSH (ie, the available NPSH is less than the required NPSH).

6.0 ASSESSMENT OF VIBRATION LEVELS

The following assessment of the severity of the vibration levels measured on the moderator pumpsets and piping are based on available vibration standards, engineering judgment and experience.

There are, at present, no vibration standards which specify transient vibration (casing velocity or shaft displacement) limits for centrifugal pumpsets. With regards to steady state limits for shaft displacement, the API 610 states, as a guideline, that the unfiltered shaft vibration measured on a centrifugal pump operating at rated speed and within 10 percent above or below rated capacity should not exceed 63.5 μm p-p /4/. Several standards for steady state casing velocity exist and limits may vary depending on the type of machine, support, etc. However, most of these standards generally agree that casing velocities exceeding approximately 18 mm/s peak are unacceptable for long term operation.

With the exception of Test No 3 Dump Test, the maximum overall velocity levels measured on the operating pumpsets during the three HPECI tests are considered high. However, because the pumpsets are subjected to these high overall velocity levels for relatively short durations, it is possible that the motors were not damaged mechanically during the tests. This assumes that the motors did not experience similarly high levels in the past. However, if the motors were subjected to similarly high levels in the past, or are expected to experience high levels in the future, then the cumulative fatigue damage to the various motor components should be determined. This may be difficult to do.

The displacement levels measured on the pump shafts during the three tests, are considered unacceptable. It is believed that mechanical damage of the pumpsets could result from operation at these high shaft displacement levels. Since the specified pump bushing diametral clearance is 150 μm, it is likely that the pump bushing of the operating pumpsets rubbed during portions of the tests.

With the exception of the Test No 3 Moderator Dump Test, the maximum overall velocities measured on the piping close to EJ3 and EJ4 exceed 40 mm/s. These levels, though high, are not likely to cause damage during the short term transients. However, if the piping may have been subjected to similarly high levels in the past, or is expected to experience high levels in the future, then the piping stresses and the cumulative fatigue damage should be determined.

The maximum piping displacement levels measured close to the expansion joints EJ-3 and EJ-4 do not exceed the "steady state" vibration limits during the three HPECI tests.

7.0 MEASURING SHAFT RUNOUT

Any appreciable amount of shaft bow or runout (any deviation in the observed shaft surface which produces a transducer output that is not related to shaft motion) can produce a misleading vibration measurement. This bow or runout vectorially combines with true shaft motion to produce the total signal sensed by the transducer. To circumvent this problem, the filtered 1 x RPM shaft displacement at a slow shaft speed can be obtained (during rundown) and stored. At the operating speed, this slowroll displacement measurement can be vectorially subtracted from the new filtered 1 x RPM displacement to yield a displacement level (filtered 1 x RPM) compensated for shaft bow and runout.

Slowroll measurements (ie filtered 1 x RPM levels) obtained on the pumpsets during rundown are shown in Table 21. Very high runouts were measured for Pumpsets P3 (140 μm p-p) and P2 (147 μm p-p). It is believed that at the lower speeds the pump shaft exhibits some wobble which results in large amplitude displacements. These displacement levels are not considered to be indicative of true shaft runout. Consequently, compensated shaft displacements could not be determined.

The total shaft runout was measured by Pickering Mechanical Maintenance. This was accomplished by setting up a dial indicator below the coupling onto the pump shaft and then slowly rotating the shaft by hand. The total indicated runout was approximately 25 μm p-p for Pumpset P2. The moderator pump maintenance procedure for seal conversion requires that the maximum acceptable runout be 2 mils (51 μm p-p). It was indicated by Pickering Operations that since the seal conversion is basically complete in Pickering NGS 'A', it is likely that all of the moderator pumpsets have pump shaft runouts that are less than 51 μm p-p /5/.

8.0 POSSIBLE MODES OF PUMPSET FAILURE

Failure of the moderator pumpsets due to high vibration levels can occur in several ways. High motor casing velocities can result in premature motor bearing failures. Stator components can also be damaged.

High shaft displacements can result in wiping of the pump bushing. If the bushing's clearance is increased sufficiently (due to the rubbing action) then the radius of the shaft orbit may increase. Wiping of the seals will likely follow. The wear rings may also be rubbed. During the foregoing process the pump shaft will be subjected to high loads and failure is possible. Seizure of the pump is also possible.

9.0 METHODS USED TO DETERMINE PUMPSET HEALTH

It appears that Pickering NGS presently determines the mechanical health of the moderator pumpsets by performing an alignment check of the pump-motor shafts. If the alignment is within 0.002 mils (TIR) then the pumpset is assumed to be in good mechanical condition. Although proper alignment is required for smooth operation, it is not considered to be a sufficient indicator of machinery health. The pumpset dynamics while operating must be considered. For example, unbalance which can generate high forces at operating speed will not be detected by an alignment check. Vibration, on the other hand, has proved to be a good indicator of pumpset health. Vibration analysis has been used to detect unbalance, misalignment, antifriction bearing defects, rotor/stator defects and many other pumpset related problems. It is strongly recommended that the vibration transducers previously installed on the moderator pumpsets, namely, a velocity (seismic) transducer at the top of the motor and a displacement transducer at the pump coupling, be reinstalled (if not present). The signals from these transducers should be periodically monitored for changes in vibration levels.

10.0 CONCLUSIONS

10.1 With the exception of Test No 3 Dump Test, the maximum overall velocity levels measured on the operating pumpsets during the three HPECI tests are considered high. However, because the pumpsets are subjected to these high overall velocity levels for relatively short durations, it is possible that the motors were not damaged mechanically during the tests. However, if the motors were subjected to similarly high levels in the past, or are expected to experience high levels in the future, then the cumulative fatigue damage to the various motor components should be determined.

10.2 The displacement levels measured on the pump shafts during the three tests, are considered unacceptable. It is believed that mechanical damage to the pumpsets could result from operation at these high shaft displacement levels. It is likely that the pump bushing of the operating pumpsets rubbed during portions of the tests.

10.3 The overall shaft displacement levels measured on pumpsets P2, P3 and P5, during normal steady state conditions, are considered high for long term operation.

10.4 With the exception of the Test No 3 Moderator Dump Test, the maximum overall velocities measured on the piping close to EJ3 and EJ4 exceed 40 mm/s. These levels, though high, are not likely to cause damage during the short term transients. However, if the piping was subjected to similarly high levels in the past, or is expected to experience high levels in the future, then the piping stresses and the cumulative fatigue damage should be determined.

10.5 The maximum piping displacement levels measured close to the expansion joints EJ-3 and EJ-4 do not exceed the "steady state" vibration limits during the three tests.

10.6 For all three tests, the pumpsets' vibration levels generally show an increase when there is insufficient NPSH.

10.7 Based on the high vibration levels measured during the tests, there is no guarantee that the moderator pumpsets will perform satisfactorily should they be subjected to similarly high vibration levels in the future.

11.0 RECOMMENDATIONS

11.1 At the earliest opportunity, a detailed investigation should be carried out to determine the cause of the high shaft displacement levels measured on pumpsets P2, P3 and P5 during normal steady state operation. Balancing of the pumpsets may be required. Vibration measurements should be obtained on pumpset P4 at normal steady state conditions, so that the health of this pumpset can be assessed.

11.2 The pumpsets should be inspected for mechanical damage. This inspection would give an indication of the possible damage to the pumpset components (eg, pump bushing, seal) due to the high vibration levels. Since the higher vibration levels were generally measured on pumpsets P3 and P5 during the tests, either of these two pumpsets should be inspected.

11.3 The vibration transducers previously installed on the moderator pumpsets, namely, a velocity (seismic) transducer at the top of the motor and a displacement transducer at the pump coupling, should be reinstalled (if not present). The signals from these transducers should be periodically monitored for changes in vibration levels.

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1. Mistry J.K, "Pickering A Unit 2 Moderator Dump and CIV Closure Tests and Recovery Transition Analysis", Oct. 1988.

2. Koehler H.P., "Vibration Signature Analysis of Pumpsets at Ontario Hydro", Sept 1974.

3. Memorandum, J.A. Blasko to P.R. Maughan, 20 June 1988, File Na-44-33350-P, "Dump and CIV Closure Tests".

4. "Centrifugal Pumps for General Refinery Services", API Standard 610, Sixth Edition, January 1981.

5. Inter-office Memorandum, P. Maughan to J. Blasko, 23 Sept. 1988, File P-33350, "HPECI- Unit 2 Commissioning Tests (Pump Vibration Readings)".

TABLE 1

INSTRUMENT LIST

1.	Accelerometer	Bruel & Kjaer Model 4384 Model 4370
2.	Charge Amplifier	Bruel & Kjaer Model 2635
3.	Displacement Transducers	Bently Nevada 7200 Series 5mm
4.	Filter	Krohn-Hite Model 3343
5.	Digital Vector Filter	Bently Nevada DVF 3
6.	Visicorder	Honeywell Model 1858
7.	FFT Analyzer	Ono Sokki CF 920
8.	Digital Plotter	Hewlett-Packard Model 7470A
9.	Tape Recorder	Honeywell 101

TABLE 2
PICKERING NGS 'A' UNIT 2 MODERATOR PUMPSETS - MOTOR CASING VELOCITY LEVELS
BASELINE MEASUREMENTS

Measurement Location and Direction	Overall Velocity Level (mm/s pk)	Filtered 1 x RPM (30 Hz) Velocity Level (mm/s pk)	Figure No. of Baseline Spectra
Top of Motor			
Pumpset P1 East-West	5.0 - 11.0	1.7	22
Pumpset P1 North-South	4.0 - 8.0	1.6	23
Pumpset P2 East-West	5.0 - 9.9	1.2	24
Pumpset P2 North-South	5.0 - 10.0	2.4	25
Pumpset P3 East-West	6.0 - 12.0	1.3	26
Pumpset P3 North-South	4.4 - 12.0	1.3	27
Pumpset P4 East-West	-	-	-
Pumpset P4 North-South	-	-	-
Pumpset P5 East-West	6.3 - 10.7	4.0	28
Pumpset P5 North-South	4.4 - 8.5	1.1	29

Note : Pumpsets P1, P2, P3 and P5 were operating under normal steady state flow conditions. (P4 was not running.)

TABLE 3
PICKERING NGS 'A' UNIT 2 MODERATOR PUMPSETS - PUMP SHAFT DISPLACEMENT LEVELS
BASELINE MEASUREMENTS

Measurement Location and Direction	Overall Displacement Level (μm p-p)	Filtered 1 x RPM (30 Hz) Displacement Level (μm p-p)	Figure No. of Baseline Spectra
Below Coupling			
Pumpset P1 East-West	88 - 100	53.2	30
Pumpset P1 North-South	81 - 100	58.7	31
Pumpset P2 East-West	165 - 178	134	32
Pumpset P2 North-South	165 - 185	135	33
Pumpset P3 East-West	195 - 215	185	34
Pumpset P3 North-South	-	-	-
Pumpset P4 East-West	-	-	-
Pumpset P4 North-South	-	-	-
Pumpset P5 East-West	145 - 170	125	35
Pumpset P5 North-South	150 - 170	135	36

Note : Pumpsets P1, P2, P3 and P5 were operating under normal steady state flow conditions. (P4 was not running.)

TABLE 4
PICKERING NGS 'A' UNIT 2 MODERATOR PUMPSETS - MOTOR CASING OVERALL VELOCITY LEVELS
TEST NO. 1 - DUMP TEST (4 JULY 1988)

Measurement Location and Direction	Time Duration (sec.)* that Overall Velocity Level exceeds				Maximum Overall Velocity Level (mm/s pk)	Vibration/Time Plot Figure No.	Velocity Spectra Figure No.	
	20 mm/s pk	40 mm/s pk	50 mm/s pk	80 mm/s pk			Loc.#1	Loc.#2
Top of Motor								
Pumpset P1 East-West	-	-	-	-	-	-	-	-
Pumpset P1 North-South	80	10	1	0	60	4	37	59
Pumpset P2 East-West	100	10	0	0	50	4	38	60
Pumpset P2 North-South	125	30	1	0	55	4	39	61
Pumpset P3 East-West	115	50	8	0	80	5	40	62
Pumpset P3 North-South	80	15	1	0	55	5	41	63
Pumpset P4 East-West	85	15	6	0	73	5	42	64
Pumpset P4 North-South	-	-	-	-	-	-	-	-
Pumpset P5 East-West	110	30	10	3	100	4	43	65
Pumpset P5 North-South	90	20	12	5	100	4	44	66

Note : Pumpsets P1, P2, P3 and P5 were operating during the test. (P4 was not running.)
Duration of Test No. 1 - Dump Test was 157 seconds approximately (Start of dump to shutdown of Pumpset P3).

* All times are approximate.

TABLE 5
PICKERING NGS 'A' UNIT 2 MODERATOR PUMPSETS - PUMP SHAFT OVERALL DISPLACEMENT LEVELS
TEST NO. 1 - DUMP TEST (4 JULY 1988)

Measurement Location and Direction	Time Duration (sec.)* that Overall Displacement Level exceeds					Maximum Overall Displacement Level (μm p-p)	Vibration/Time Plot Figure No.	Displacement Spectra Figure No.	
	100 μm p-p	150 μm p-p	200 μm p-p	300 μm p-p	400 μm p-p			Loc.#1	Loc.#2
Below Coupling									
Pumpset P1 East-West	157	140	70	0	0	275	4	45	67
Pumpset P1 North-South	157	140	80	10	0	330	4	46	68
Pumpset P2 East-West	157	157	90	25	4	440	6	47	69
Pumpset P2 North-South	157	157	157	10	0	360	6	48	70
Pumpset P3 East-West	157	157	157	30	0	395	5	49	71
Pumpset P3 North-South	-	-	-	-	-	-	-	-	-
Pumpset P4 East-West	6	0	0	0	0	120	5	50	72
Pumpset P4 North-South	0	0	0	0	0	87	5	-	-
Pumpset P5 East-West	157	157	70	35	10	480	6	51	73
Pumpset P5 North-South	157	157	45	15	4	472	6	52	74

Note : Pumpsets P1, P2, P3 and P5 were operating during the test. (P4 was not running.)
Duration of Test No. 1 - Dump Test was 157 seconds approximately (Start of dump to shutdown of Pumpset P3).

* All times are approximate.

TABLE 6
PICKERING NGS 'A' UNIT 2 MODERATOR PUMPSETS - PIPING (NEAR EXPANSION JOINT) OVERALL VELOCITY AND DISPLACEMENT LEVELS
TEST NO. 1 - DUMP TEST (4 JULY 1988)

Measurement Location and Direction	Time Duration (sec.)* that Overall Velocity Level exceeds			Maximum Overall Velocity Level (mm/s pk)	Maximum Overall Displacement Level (mm p-p)	Vibration/Time Plot Figure No.	Velocity Spectra Figure No.	
	40 mm/s pk	60 mm/s pk	80 mm/s pk				Loc.#1	Loc.#2
EJ-3 Vertical	6	1	0	65	1.6	7,8	53	75
EJ-3 Horizontal	6	0	0	60	1.6	7,8	54	76
EJ-3 Axial	6	1	0	65	1.3	7,8	55	77
EJ-4 Vertical	16	6	2	100	3.8	7,8	56	78
EJ-4 Horizontal	24	12	3	120	-	7	57	79
EJ-4 Axial	15	2	0	70	1.0	7,8	58	80

Note : Pumpsets P1, P2, P3 and P5 were operating during the test. (P4 was not running.)
Duration of Test No. 1 - Dump Test was 157 seconds approximately (Start of dump to shutdown of Pumpset P3).

* All times are approximate.

TABLE 7
PICKERING NGS 'A' UNIT 2 MODERATOR PUMPSETS - MOTOR CASING OVERALL VELOCITY LEVELS
TEST NO. 2 - DUMP TEST (18 JULY 1988)

Measurement Location and Direction	Time Duration (sec.)* that Overall Velocity Level exceeds				Maximum Overall Velocity Level (mm/s pk)	Vibration/Time Plot Figure No.	Velocity Spectra Figure No.
	20 mm/s pk	40 mm/s pk	50 mm/s pk	80 mm/s pk			
Top of Motor							
Pumpset P1 East-West	4	1	0	0	44	9	81
Pumpset P1 North-South	2	0	0	0	32	9	82
Pumpset P2 East-West	2	0	0	0	34	9	83
Pumpset P2 North-South	2	0	0	0	32	9	84
Pumpset P3 East-West	4	1	0	0	42	10	85
Pumpset P3 North-South	2	0	0	0	24	10	86
Pumpset P4 East-West	3	2	1	0	52	10	87
Pumpset P4 North-South	-	-	-	-	-	-	-
Pumpset P5 East-West	7	1	0	0	50	9	88
Pumpset P5 North-South	2	0	0	0	32	9	89

Note : Pumpsets P1, P2, P3 and P5 were operating during the test. (P4 was not running.)
Duration of Test No. 2 - Dump Test was 285 seconds approximately (Start of dump to CIV closure).

* All times are approximate.

TABLE 8
PICKERING NGS 'A' UNIT 2 MODERATOR PUMPSETS - PUMP SHAFT OVERALL DISPLACEMENT LEVELS
TEST NO. 2 - DUMP TEST (18 JULY 1988)

Measurement Location and Direction	Time Duration (sec.)* that Overall Displacement Level exceeds				Maximum Overall Displacement Level (µm p-p)	Vibration/Time Plot Figure No.	Displacement Spectra Figure No.
	100 µm p-p	150 µm p-p	200 µm p-p	300 µm p-p			
Below Coupling							
Pumpset P1 East-West	285	5	2	0	240	9	90
Pumpset P1 North-South	285	5	3	0	275	9	91
Pumpset P2 East-West	285	285	285	0	275	11	92
Pumpset P2 North-South	285	285	285	2	325	11	93
Pumpset P3 East-West	285	285	285	0	295	10	94
Pumpset P3 North-South	-	-	-	-	-	-	-
Pumpset P4 East-West	0	0	0	0	50	10	95
Pumpset P4 North-South	0	0	0	0	47	10	-
Pumpset P5 East-West	285	285	4	0	285	11	96
Pumpset P5 North-South	285	285	4	0	236	11	97

Note : Pumpsets P1, P2, P3 and P5 were operating during the test. (P4 was not running.)
Duration of Test No. 2 - Dump Test was 285 seconds approximately. (Start of dump to CIV Closure).

* All times are approximate.

TABLE 9
PICKERING NGS 'A' UNIT 2 MODERATOR PUMPSETS - PIPING (NEAR EXPANSION JOINT)
OVERALL VELOCITY AND DISPLACEMENT LEVELS
TEST NO. 2 - DUMP TEST (18 JULY 1988)

Measurement Location and Direction	Time Duration (sec.)* that Overall Velocity Level exceeds 40 mm/s pk	Maximum Overall Velocity Level (mm/s pk)	Maximum Overall Displacement Level (mm p-p)	Vibration/Time Plot Figure No.	Velocity Spectra Figure No.
EJ-3 Vertical	4	87	< 0.2	12,13	98
EJ-3 Horizontal	4	87	< 0.1	12,13	99
EJ-3 Axial	4	75	< 0.1	12,13	100
EJ-4 Vertical	-	-	-	-	-
EJ-4 Horizontal	3	62	< 0.1	12,13	101
EJ-4 Axial	3	62	< 0.1	12,13	102

Note : Pumpsets P1, P2, P3 and P5 were operating during the test. (P4 was not running.)
Duration of Test No. 2 - Dump Test was 285 seconds approximately (Start of dump to CIV closure).

* All times are approximate.

TABLE 10
PICKERING NGS 'A' UNIT 2 MODERATOR PUMPSETS - MOTOR CASING OVERALL VELOCITY LEVELS
TEST NO. 2 - CIV CLOSURE TEST (18 JULY 1988)

Measurement Location and Direction	Time Duration (sec.)* that Overall Velocity Level exceeds				Maximum Overall Velocity Level (mm/s pk)	Vibration/Time Plot Figure No.	Velocity Spectra Figure No.
	20 mm/s pk	40 mm/s pk	50 mm/s pk	80 mm/s pk			
Top of Motor							
Pumpset P1 East-West	15	5	4	2	95	9	103
Pumpset P1 North-South	14	4	1	0	67	9	104
Pumpset P2 East-West	12	5	1	0	63	9	105
Pumpset P2 North-South	12	8	6	4	107	9	106
Pumpset P3 East-West	16	5	3	0	80	10	107
Pumpset P3 North-South	13	8	4	2	112	10	108
Pumpset P4 East-West	2	0	0	0	32	10	109
Pumpset P4 North-South	-	-	-	-	-	-	-
Pumpset P5 East-West	15	0	0	0	40	9	110
Pumpset P5 North-South	5	1	0	0	44	9	111

Note : Pumpsets P1, P2, P3 and P5 were operating during the test. (P4 was not running.)
Duration of Test No. 2 - CIV Closure Test was 178 seconds approximately (CIV closure to controller failure).

* All times are approximate.

TABLE 11
PICKERING NGS 'A' UNIT 2 MODERATOR PUMPSETS - PUMP SHAFT OVERALL DISPLACEMENT LEVELS
TEST NO. 2 - CIV CLOSURE TEST (18 JULY 1988)

Measurement Location and Direction	Time Duration (sec.)* that Overall Displacement Level exceeds				Maximum Overall Displacement Level (µm p-p)	Vibration/Time Plot Figure No.	Displacement Spectra Figure No.
	100 µm p-p	150 µm p-p	200 µm p-p	300 µm p-p			
Below Coupling							
Pumpset P1 East-West	178	174	160	0	278	9	112
Pumpset P1 North-South	178	174	174	0	280	9	113
Pumpset P2 East-West	178	178	100	0	280	11	114
Pumpset P2 North-South	178	178	178	2	327	11	115
Pumpset P3 East-West	178	178	178	0	300	10	116
Pumpset P3 North-South	-	-	-	-	-	-	-
Pumpset P4 East-West	0	0	0	0	50	10	117
Pumpset P4 North-South	0	0	0	0	44	10	-
Pumpset P5 East-West	178	178	15	0	240	11	118
Pumpset P5 North-South	178	178	0	0	190	11	119

Note : Pumpsets P1, P2, P3 and P5 were operating during the test. (P4 was not running.)
Duration of Test No. 2 - CIV Closure Test was 178 seconds approximately. (CIV closure to controller failure).

* All times are approximate.

TABLE 12
PICKERING NGS 'A' UNIT 2 MODERATOR PUMPSETS - PIPING (NEAR EXPANSION JOINT)
OVERALL VELOCITY AND DISPLACEMENT LEVELS
TEST NO. 2 - CIV CLOSURE TEST (18 JULY 1988)

Measurement Location and Direction	Time Duration (sec.)* that Overall Velocity Level exceeds 40 mm/s pk	Maximum Overall Velocity Level (mm/s pk)	Maximum Overall Displacement Level (mm p-p)	Vibration/Time Plot Figure No.	Velocity Spectra Figure No.
EJ-3 Vertical	7	75	0.5	12,13	120
EJ-3 Horizontal	7	50	0.4	12,13	121
EJ-3 Axial	8	75	0.4	12,13	122
EJ-4 Vertical	-	-	-	-	-
EJ-4 Horizontal	6	75	0.3	12,13	123
EJ-4 Axial	0	40	0.3	12,13	124

Note : Pumpsets P1, P2, P3 and P5 were operating during the test. (P4 was not running.)
Duration of Test No. 2 - CIV Closure Test was 178 seconds approximately (CIV closure to controller failure).

* All times are approximate.

TABLE 13
PICKERING NGS 'A' UNIT 2 MODERATOR PUMPSETS - MOTOR CASING OVERALL VELOCITY LEVELS
TEST NO. 2 - CONTROLLER FAILURE EVENT (18 JULY 1988)

Measurement Location and Direction	Time Duration (sec.)* that Overall Velocity Level exceeds				Maximum Overall Velocity Level (mm/s pk)	Vibration/Time Plot Figure No.
	20 mm/s pk	40 mm/s pk	50 mm/s pk	80 mm/s pk		
Top of Motor						
Pumpset P1 East-West	3	2	1	1	84	9
Pumpset P1 North-South	3	1	1	0	66	9
Pumpset P2 East-West	2	1	1	0	80	9
Pumpset P2 North-South	3	1	0	0	48	9
Pumpset P3 East-West	4	2	1	0	72	10
Pumpset P3 North-South	2	1	1	0	80	10
Pumpset P4 East-West	2	1	1	0	60	10
Pumpset P4 North-South	-	-	-	-	-	-
Pumpset P5 East-West	2	1	0	0	48	9
Pumpset P5 North-South	2	0	0	0	40	9

Note : Pumpsets P1, P2, P3 and P5 were operating during the test. (P4 was not running.)
Duration of Test No. 2 - Contoller Failure Event was 12 seconds approximately (Controller failure to shutdown of Pumpset P3)

* All times are approximate.

TABLE 14
PICKERING NGS 'A' UNIT 2 MODERATOR PUMPSETS - PUMP SHAFT OVERALL DISPLACEMENT LEVELS
TEST NO. 2 - CONTROLLER FAILURE EVENT (18 JULY 1988)

Measurement Location and Direction	Time Duration (sec.)* that Overall Displacement Level exceeds				Maximum Overall Displacement Level (um p-p)	Vibration/Time Plot Figure No.
	100 µm p-p	150 µm p-p	200 µm p-p	300 µm p-p		
Below Coupling						
Pumpset P1 East-West	12	7	4	0	260	9
Pumpset P1 North-South	12	7	6	0	300	9
Pumpset P2 East-West	12	12	12	0	280	11
Pumpset P2 North-South	12	12	12	2	325	11
Pumpset P3 East-West	12	12	12	0	270	10
Pumpset P3 North-South	-	-	-	-	-	-
Pumpset P4 East-West	2	1	0	0	160	10
Pumpset P4 North-South	2	0	0	0	125	10
Pumpset P5 East-West	12	12	0	0	180	11
Pumpset P5 North-South	12	12	0	0	175	11

Note : Pumpsets P1, P2, P3 and P5 were operating during the test. (P4 was not running.)
Duration of Test No. 2 - Controller Failure Event was 12 seconds approximately (Controller failure to shutdown of Pumpset P3).

* All times are approximate.

TABLE 15

PICKERING NGS 'A' UNIT 2 MODERATOR PUMPSETS - MOTOR CASING OVERALL VELOCITY LEVELS

TEST NO. 3 - DUMP TEST (19 JULY 1988)

Measurement Location and Direction	Maximum Overall Velocity Level (mm/s pk)	Vibration/Time Plot Figure No.	Velocity Spectra Figure No.
Top of Motor			
Pumpset P1 East-West	-	-	-
Pumpset P1 North-South	10	14	125
Pumpset P2 East-West	10	14	126
Pumpset P2 North-South	12	14	127
Pumpset P3 East-West	-	-	-
Pumpset P3 North-South	9	15	128
Pumpset P4 East-West	7	15	129
Pumpset P4 North-South	-	-	-
Pumpset P5 East-West	10	14	130
Pumpset P5 North-South	7	14	131

Note : Pumpsets P1, P2, P3 and P5 were operating during the test. (P4 was not running.)
Duration of Test No. 3 - Dump Test was 180 seconds approximately (Start of dump to CIV closure).

TABLE 16
PICKERING NGS 'A' UNIT 2 MODERATOR PUMPSETS - PUMP SHAFT OVERALL DISPLACEMENT LEVELS
TEST NO. 3 - DUMP TEST (19 JULY 1988)

Measurement Location and Direction	Time Duration (sec.)* that Overall Displacement Level exceeds			Maximum Overall Displacement Level (µm p-p)	Vibration/Time Plot Figure No.	Displacement Spectra Figure No.
	100 µm p-p	150 µm p-p	200 µm p-p			
Below Coupling						
Pumpset P1 East-West	180	0	0	110	14	132
Pumpset P1 North-South	180	0	0	125	14	133
Pumpset P2 East-West	180	180	0	200	16	134
Pumpset P2 North-South	180	180	180	205	16	135
Pumpset P3 East-West	180	180	180	240	15	136
Pumpset P3 North-South	-	-	-	-	-	-
Pumpset P4 East-West	0	0	0	16	15	137
Pumpset P4 North-South	0	0	0	14	15	-
Pumpset P5 East-West	180	180	0	185	16	138
Pumpset P5 North-South	180	180	0	190	16	139

Note : Pumpsets P1, P2, P3 and P5 were operating during the test. (P4 was not running).
Duration of Test No. 3 - Dump Test was 180 seconds approximately (Start of dump to CIV closure).

* All times are approximate.

TABLE 17
PICKERING NGS 'A' UNIT 2 MODERATOR PUMPSETS - PIPING (NEAR EXPANSION JOINT)
OVERALL VELOCITY AND DISPLACEMENT LEVELS
TEST NO. 3 - DUMP TEST (19 JULY 1988)

Measurement Location and Direction	Maximum Overall Velocity Level (mm/s pk)	Maximum Overall Displacement Level (mm p-p)	Vibration/Time Plot Figure No.	Velocity Spectra Figure No.
EJ-3 Vertical	16	< 1.0	17,18	140
EJ-3 Horizontal	15	< 1.0	17,18	141
EJ-3 Axial	21	< 0.1	17,18	142
EJ-4 Vertical	-	-	-	-
EJ-4 Horizontal	15	< 0.5	17,18	143
EJ-4 Axial	-	< 1.0	18	144

Note : Pumpsets P1, P2, P3 and P5 were operating during the test. (P4 was not running).
Duration of Test No. 3 - Dump Test was 180 seconds approximately (Start of dump to CIV closure).

TABLE 18
PICKERING NGS 'A' UNIT 2 MODERATOR PUMPSETS - MOTOR CASING OVERALL VELOCITY LEVELS
TEST NO. 3 - CIV CLOSURE TEST (19 JULY 1988)

Measurement Location and Direction	Time Duration (sec.)* that Overall Velocity Level exceeds				Maximum Overall Velocity Level (mm/s pk)	Vibration/Time Plot Figure No.	Velocity Spectra Figure No.
	20 mm/s pk	40 mm/s pk	50 mm/s pk	80 mm/s pk			
Top of Motor							
Pumpset P1 East-West	-	-	-	-	-	-	-
Pumpset P1 North-South	45	3	1	1	85	14	145
Pumpset P2 East-West	45	3	2	0	55	14	146
Pumpset P2 North-South	45	4	2	1	100	14	147
Pumpset P3 East-West	-	-	-	-	-	-	-
Pumpset P3 North-South	40	4	2	1	86	15	148
Pumpset P4 East-West	3	0	0	0	28	15	149
Pumpset P4 North-South	-	-	-	-	-	-	-
Pumpset P5 East-West	45	0	0	0	32	14	150
Pumpset P5 North-South	45	0	0	0	35	14	151

Note : Pumpsets P1, P2, P3 and P5 were operating during the test. (P4 was not running.)
Duration of Test No. 3 - CIV Closure Test was 160 seconds approximately (CIV closure to shutdown of Pumpset P3).

* All times are approximate.

TABLE 19
PICKERING NGS 'A' UNIT 2 MODERATOR PUMPSETS - PUMP SHAFT OVERALL DISPLACEMENT LEVELS
TEST NO. 3 - CIV CLOSURE TEST (19 JULY 1988)

Measurement Location and Direction	Time Duration (sec.)* that Overall Displacement Level exceeds					Maximum Overall Displacement Level (µm p-p)	Vibration/Time Plot Figure No.	Velocity Spectra Figure No.
	100 µm p-p	150 µm p-p	200 µm p-p	300 µm p-p	400 µm p-p			
Below Coupling								
Pumpset P1 East-West	160	160	40	0	0	280	14	152
Pumpset P1 North-South	160	160	55	4	0	330	14	153
Pumpset P2 East-West	160	160	45	0	0	292	16	154
Pumpset P2 North-South	160	160	160	0	0	298	16	155
Pumpset P3 East-West	160	160	160	12	0	365	15	156
Pumpset P3 North-South	-	-	-	-	-	-	-	-
Pumpset P4 East-West	0	0	0	0	0	65	15	157
Pumpset P4 North-South	0	0	0	0	0	73	15	-
Pumpset P5 East-West	160	160	55	40	25	420	16	158
Pumpset P5 North-South	160	160	45	3	0	320	16	159

Note : Pumpsets P1, P2, P3 and P5 were operating during the test. (P4 was not running).
Duration of Test No. 3 - CIV Closure Test was 160 seconds approximately (CIV closure to shutdown of Pumpset P3).

* All times are approximate.

TABLE 20
PICKERING NGS 'A' UNIT 2 MODERATOR PUMPSETS - PIPING (NEAR EXPANSION JOINT)
OVERALL VELOCITY AND DISPLACEMENT LEVELS
TEST NO. 3 - CIV CLOSURE TEST (19 JULY 1988)

Measurement Location and Direction	Time Duration (sec.)* that Overall Velocity Level exceeds			Maximum Overall Velocity Level (mm/s pk)	Maximum Overall Displacement Level (mm p-p)	Vibration/Time Plot Figure No.	Velocity Spectra Figure No.
	40 mm/s pk	80 mm/s pk	100 mm/s pk				
EJ-3 Vertical	48	30	8	150	5.5	17,18	160
EJ-3 Horizontal	48	30	8	170	5.0	17,18	161
EJ-3 Axial	48	2	0	82	0.5	17,18	162
EJ-4 Vertical	-	-	-	-	-	-	-
EJ-4 Horizontal	48	20	0	90	2.5	17,18	163
EJ-4 Axial	-	-	-	-	6.0	18	164

Note : Pumpsets P1, P2, P3 and P5 were operating during the test. (P4 was not running.)
Duration of Test No. 3 - CIV Closure Test was 160 seconds approximately (CIV closure to shutdown of Pumpset P3).

* All times are approximate.

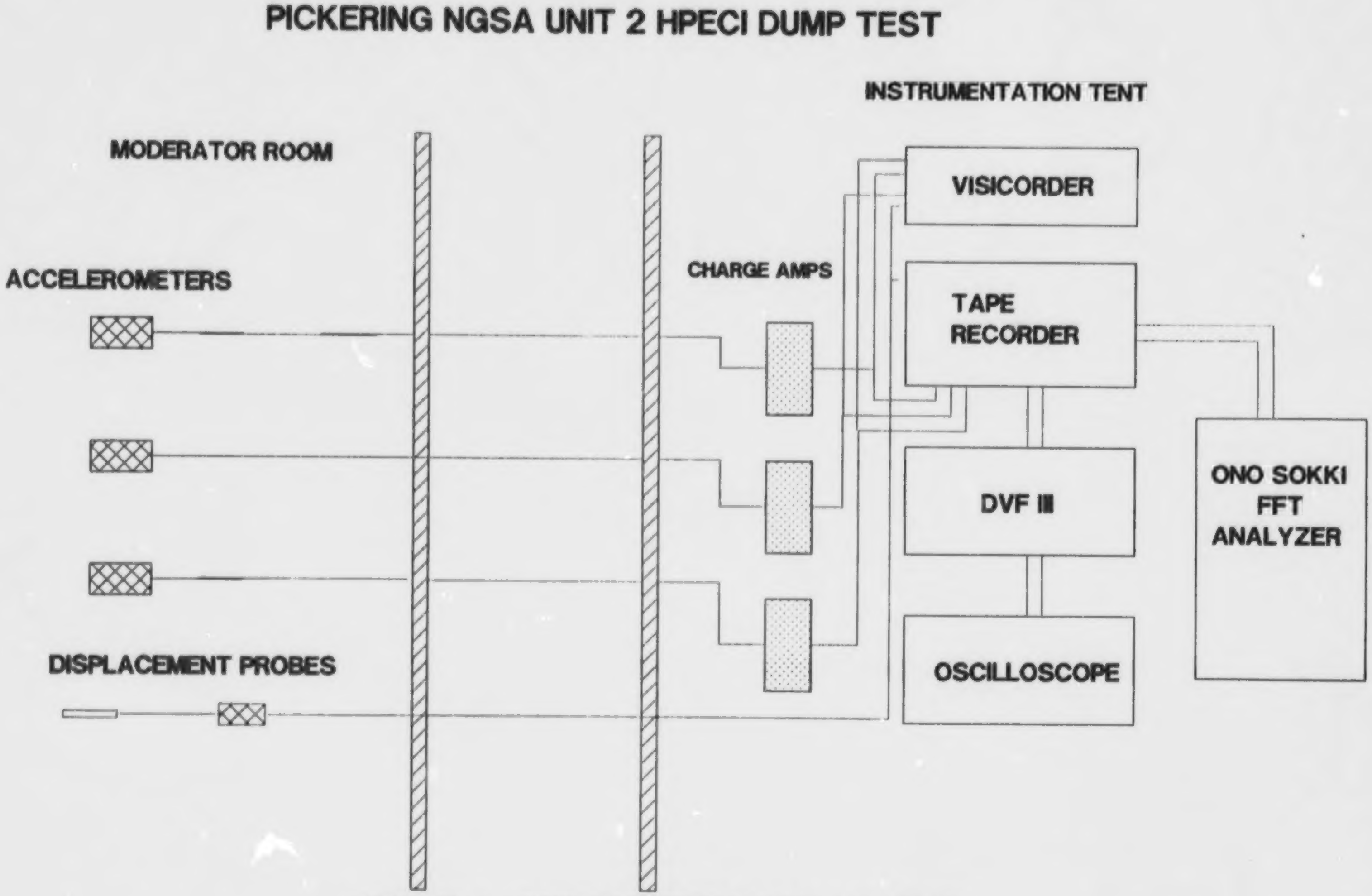

PICKERING NGSA UNIT 2 HPECI DUMP TEST
INSTRUMENTATION TENT
MODERATOR ROOM
VISICORDER
ACCELEROMETERS
CHARGE AMPS
TAPE RECORDER
DVF III
ONO SOKKI FFT ANALYZER
DISPLACEMENT PROBES
OSCILLOSCOPE

FIGURE 1 INSTRUMENTATION LAYOUT

MODERATOR PUMP MOTOR VIBRATION TRANSDUCER LOCATIONS

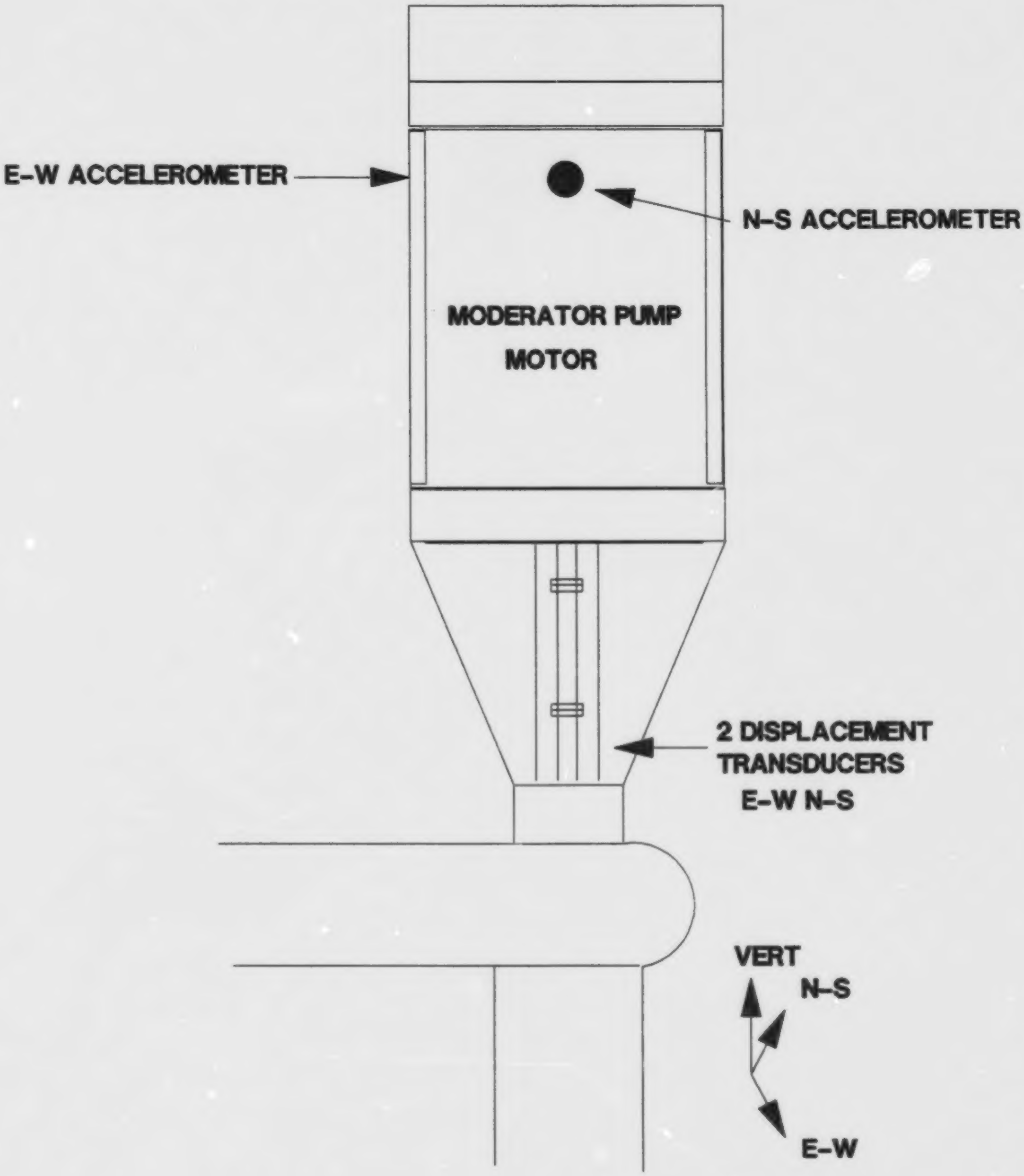
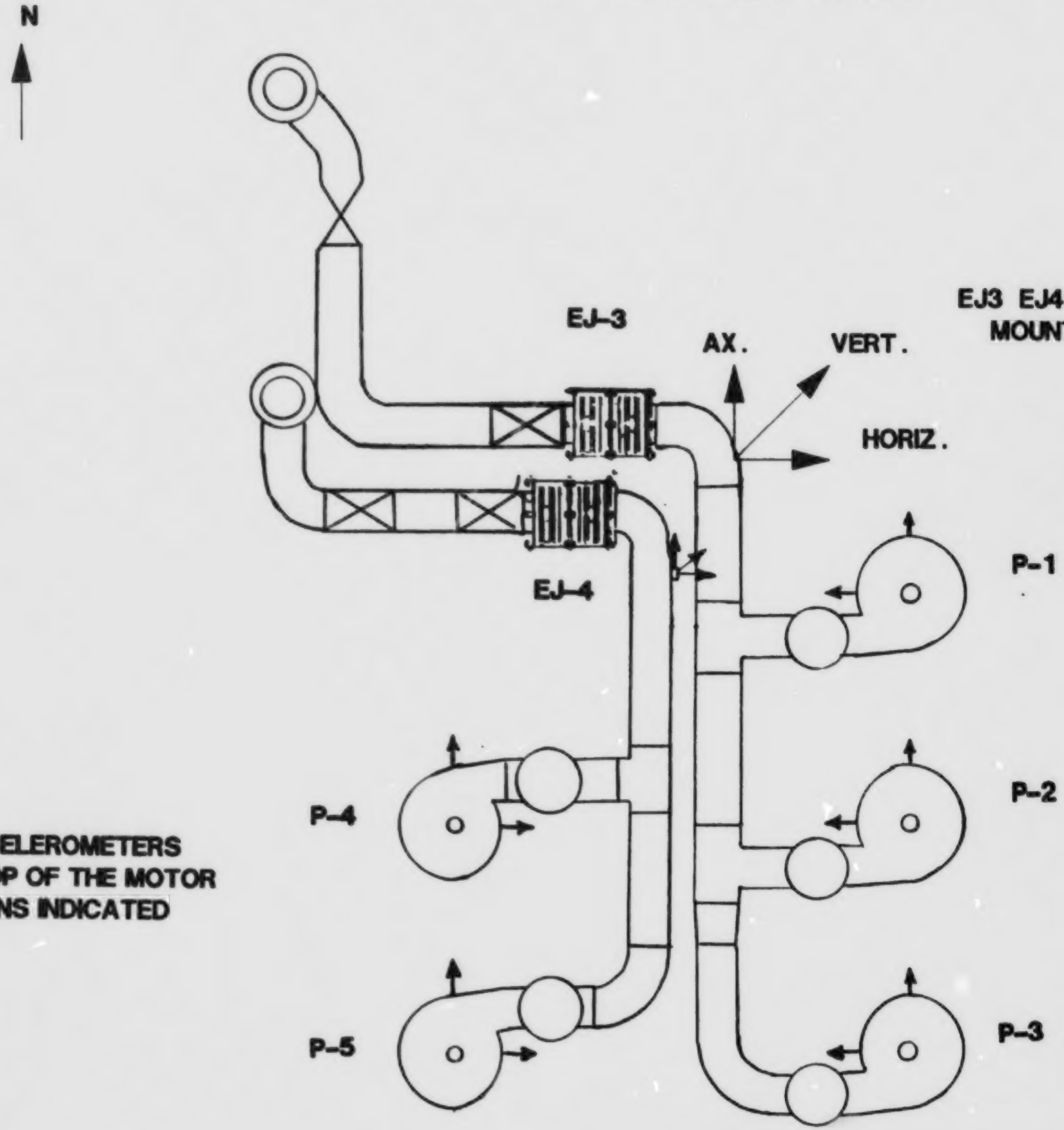

E-W ACCELEROMETER
N-S ACCELEROMETER
MODERATOR PUMP MOTOR
2 DISPLACEMENT TRANSDUCERS
E-W N-S
VERT
N-S
E-W

FIGURE 2

Figure No 3

ACCELEROMETER POSITIONS INDICATED BY ARROWS


N
EJ-3
AX.
VERT.
HORIZ.
EJ-4
P-1
P-2
P-3
P-4
P-5

EJ3 EJ4 ACCELEROMETERS
MOUNTED ON A CUBE

P-1 TO P-5 ACCELEROMETERS
MOUNTED ON TOP OF THE MOTOR
IN THE DIRECTIONS INDICATED

FIGURE 3
PICKERING NGS 'A' UNIT 2 MODERATOR PUMPSET PIPING
VIBRATION MEASUREMENT LOCATIONS AND DIRECTIONS

FIGURE 4
PICKERING NGS 'A' UNIT 2 - TEST NO. 1 (04 JULY 1988)
MODERATOR PUMPSET VIBRATION VERSUS TIME RECORD

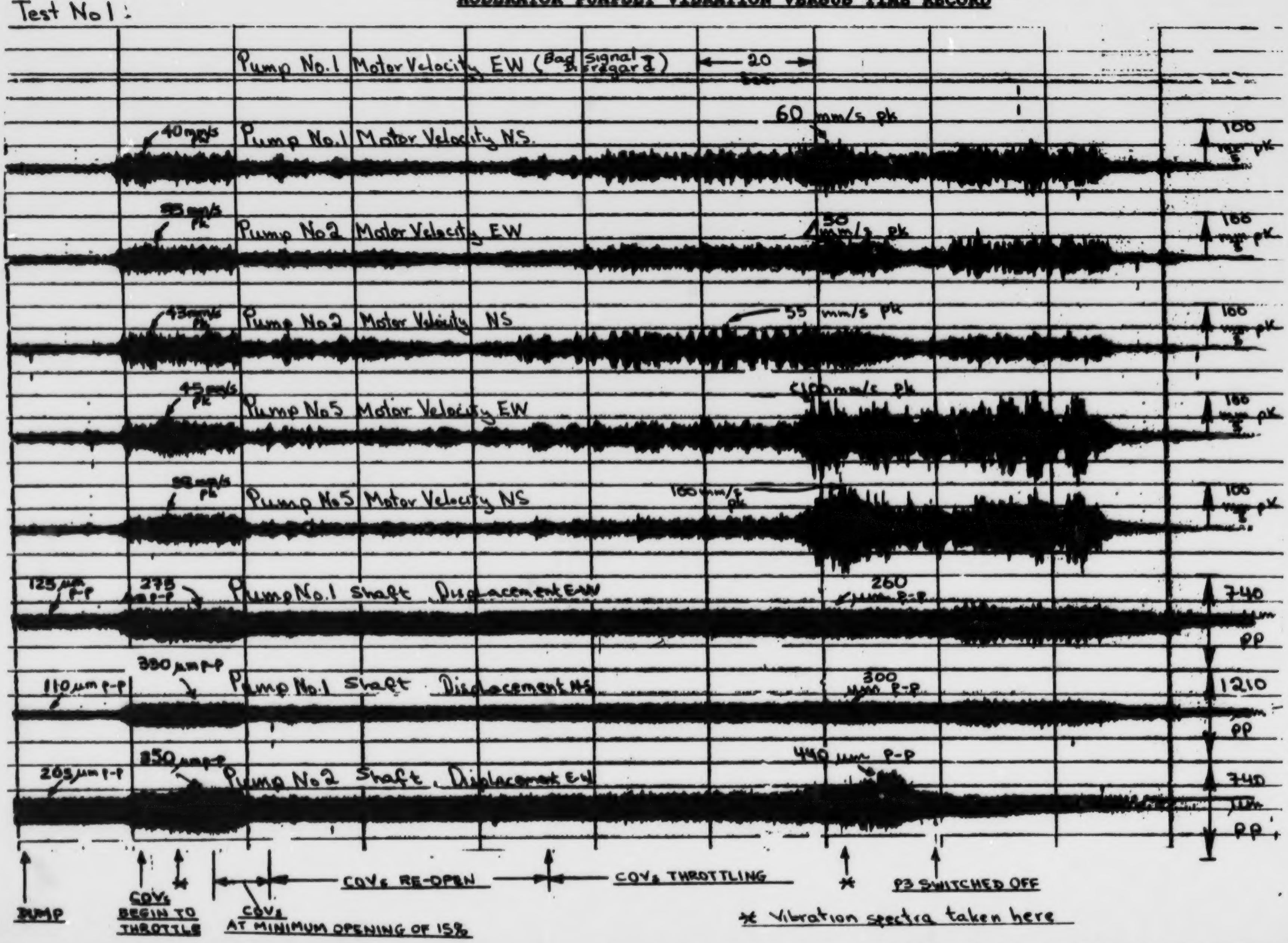


FIGURE 5

PICKERING NGS 'A' UNIT 2 - TEST NO. 1 (04 JULY 1988)
MODERATOR PUMPSET VIBRATION VERSUS TIME RECORD

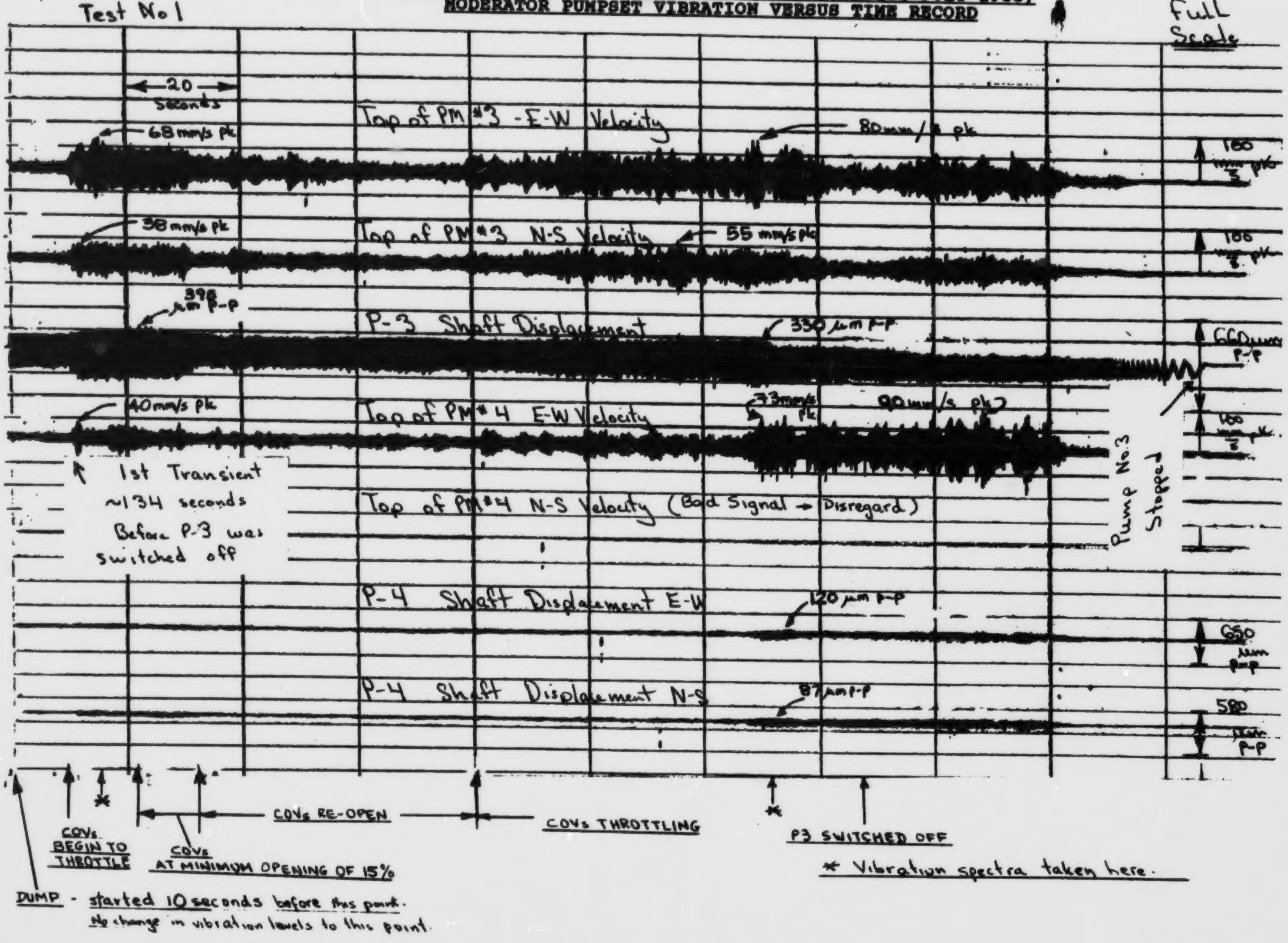


FIGURE 6

PICKERING NGS 'A' UNIT 2 - TEST NO. 1 (04 JULY 1988) MODERATOR PUMPSET VIBRATION VERSUS TIME RECORD

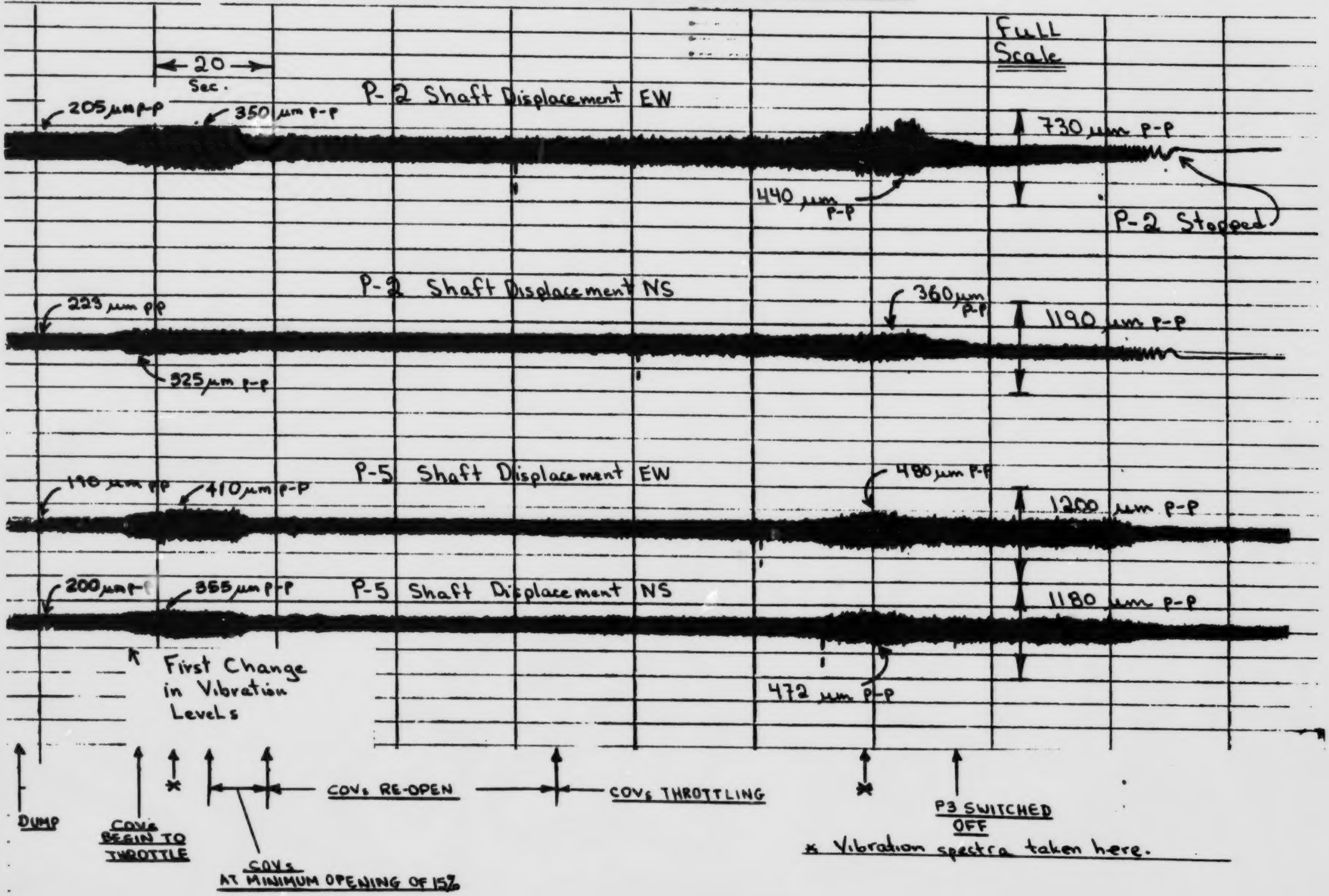


FIGURE 7

PICKERING NGS 'A' UNIT 2 - TEST NO. 1 (04 JULY 1988)
MODERATOR PUMPSET PIPING VIBRATION VERSUS TIME RECORD

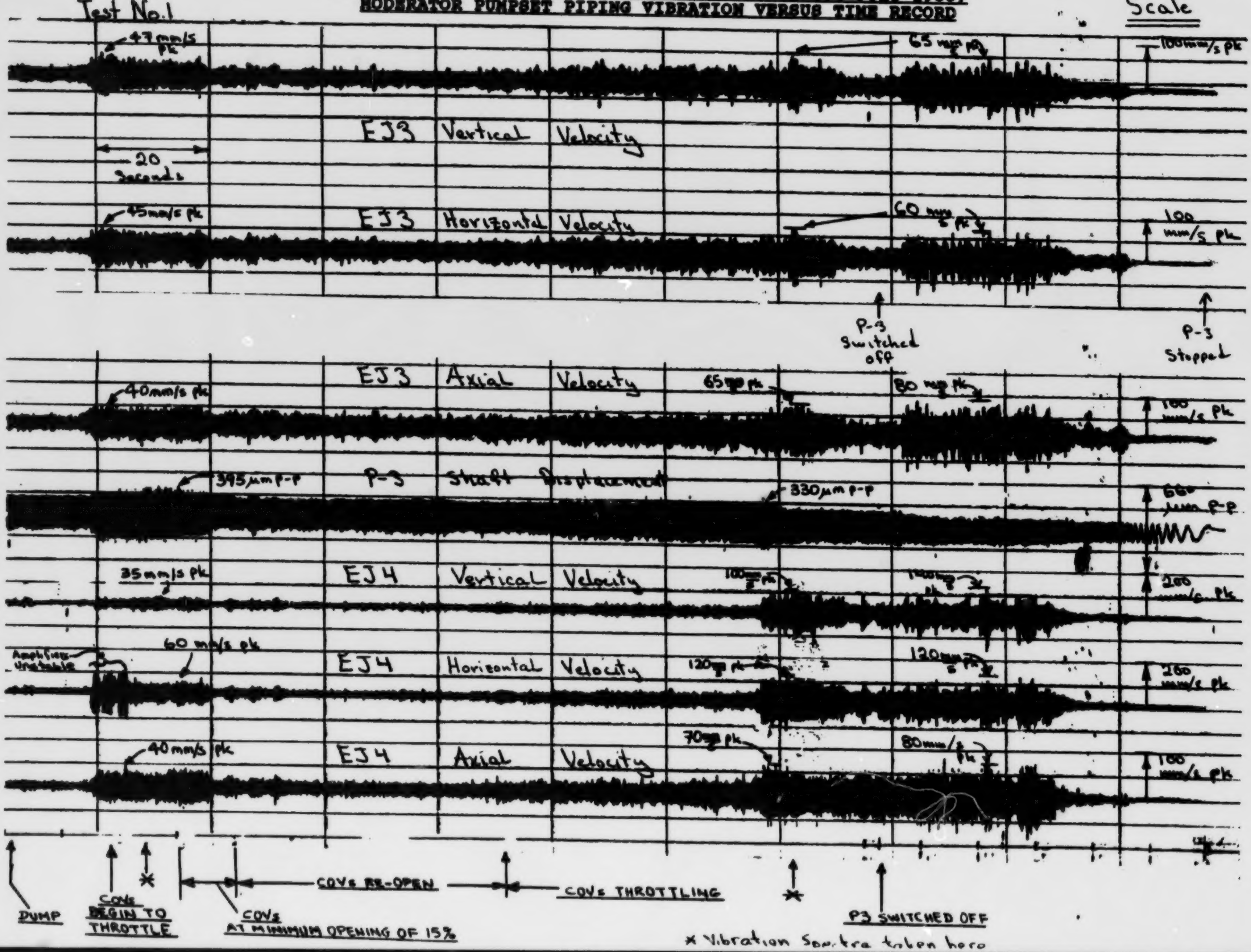


FIGURE 8

PICKERING NGS 'A' UNIT 2 - TEST NO. 1 (04 JULY 1988)
MODERATOR PUMPSET PIPING VIBRATION VERSUS TIME RECORD

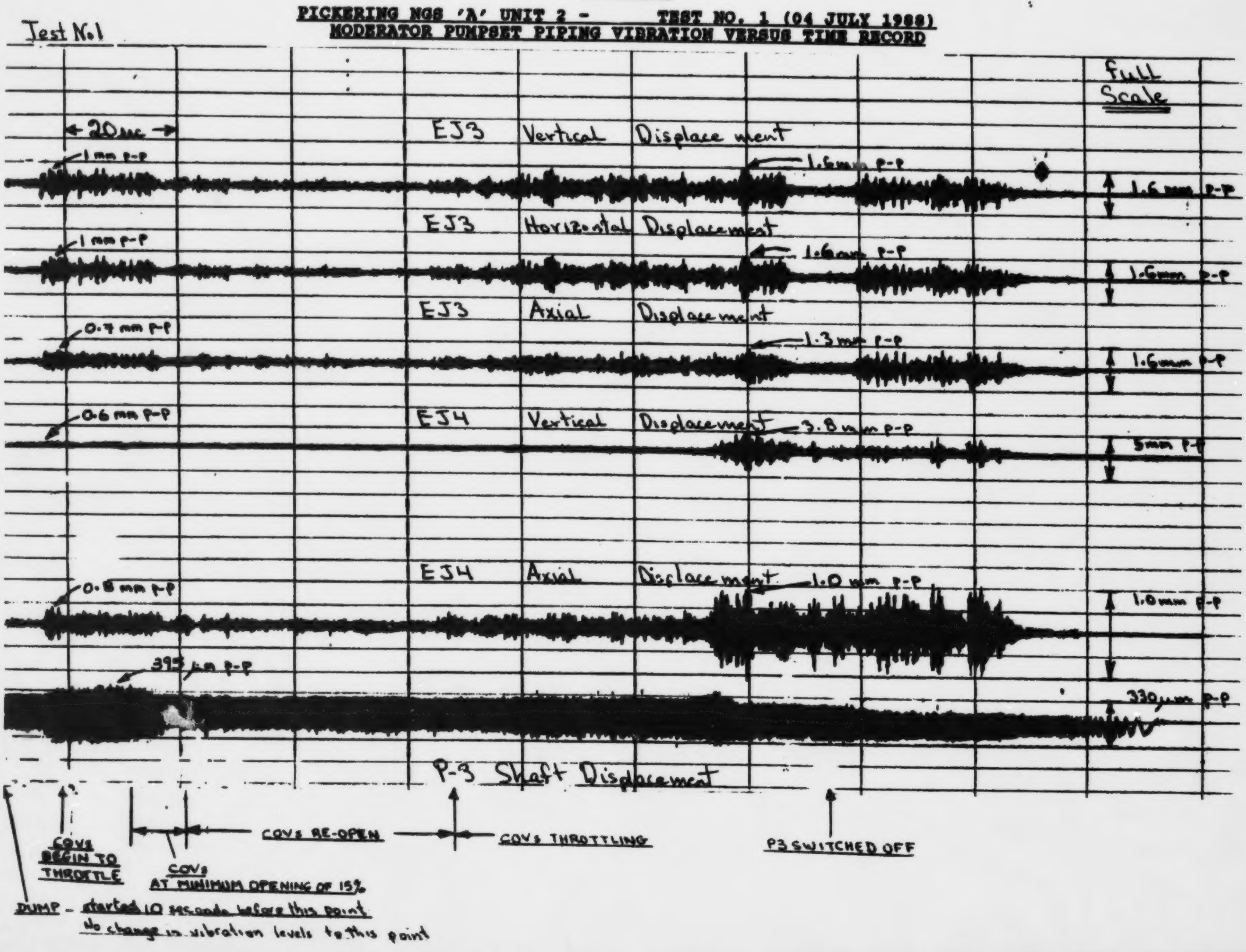


FIGURE 9

PICKERING NGS 'A' UNIT 2 - TEST NO. 2 (18 JULY 1988)
MODERATOR PUMPSET VIBRATION VERSUS TIME RECORD

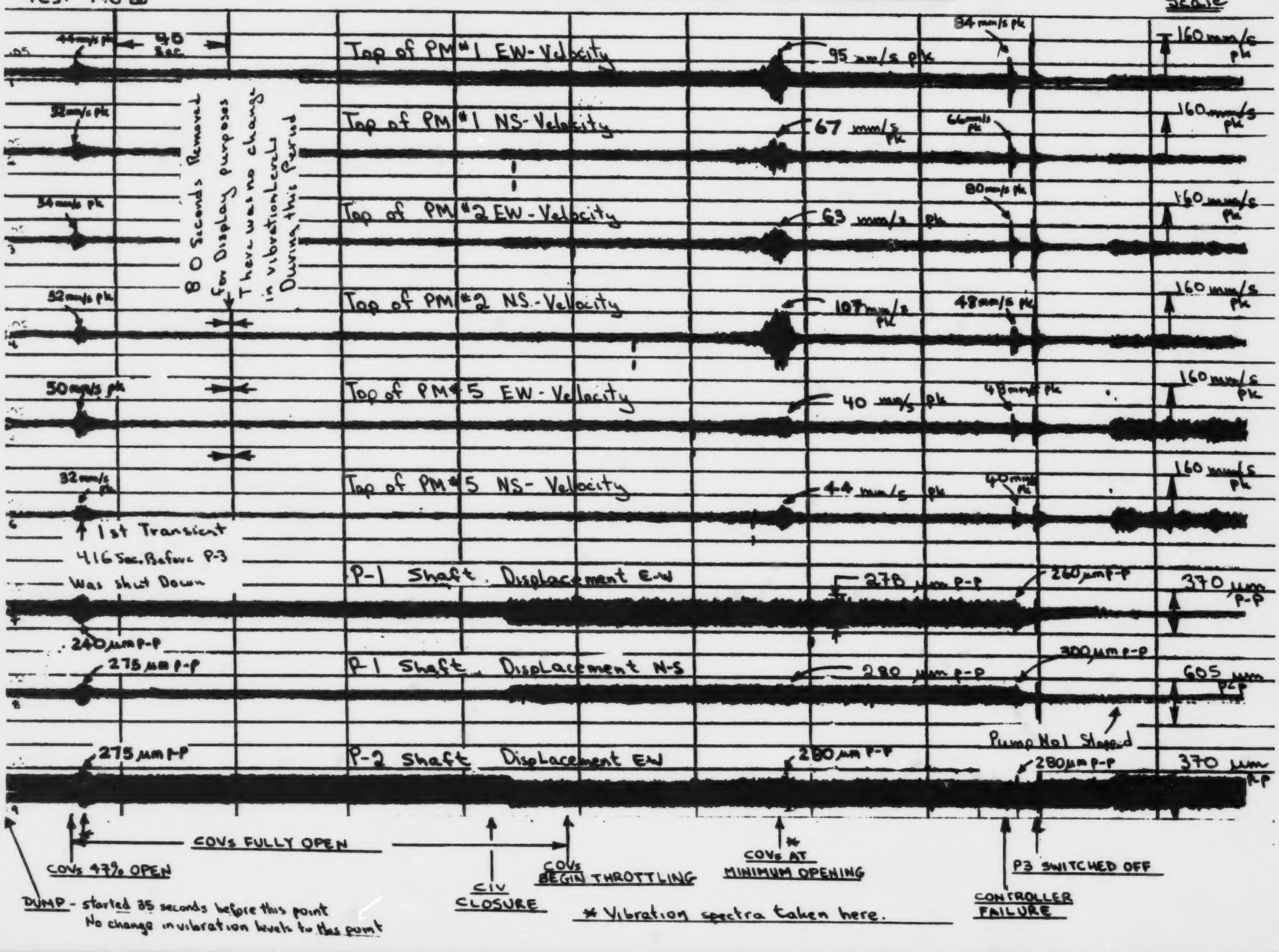
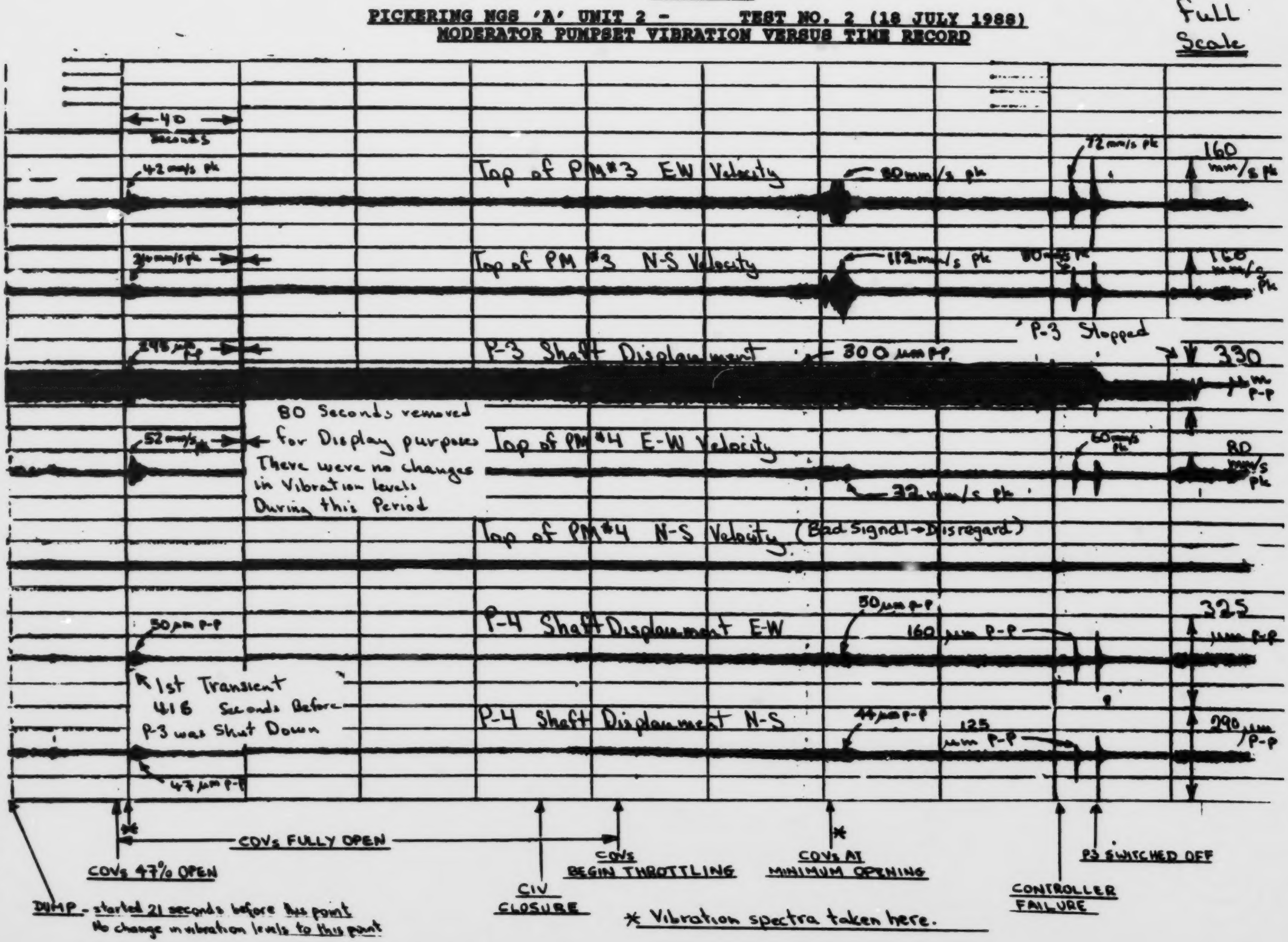


FIGURE 10

PICKERING NGS 'A' UNIT 2 - TEST NO. 2 (18 JULY 1988)
MODERATOR PUMPSET VIBRATION VERSUS TIME RECORD



DUMP - started 21 seconds before this point
No change in vibration levels to this point

* Vibration spectra taken here.

FIGURE 11

PICKERING NGS 'A' UNIT 2 - TEST NO. 2 (18 JULY 1988)

MODERATOR PUMPSET VIBRATION VERSUS TIME RECORD

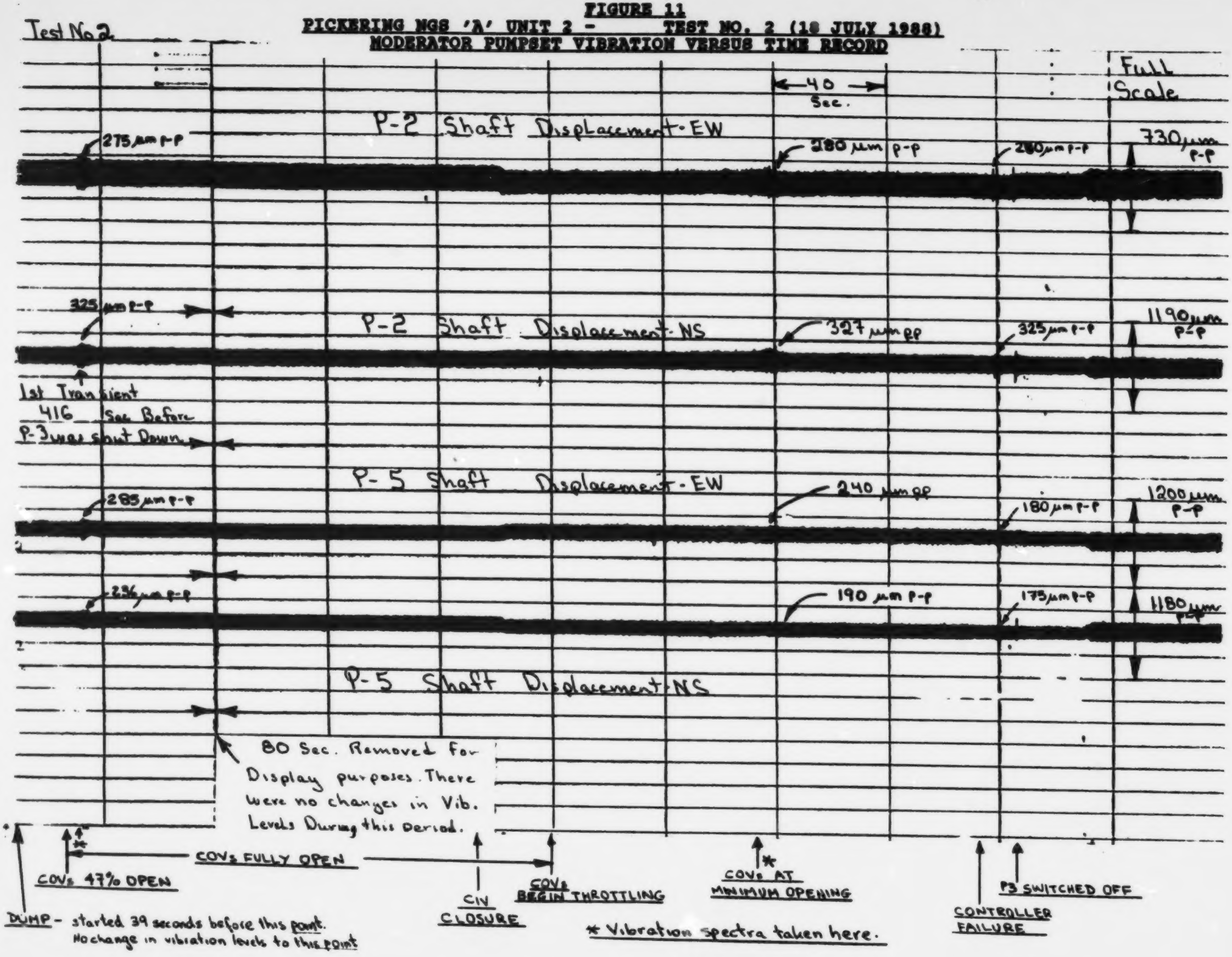
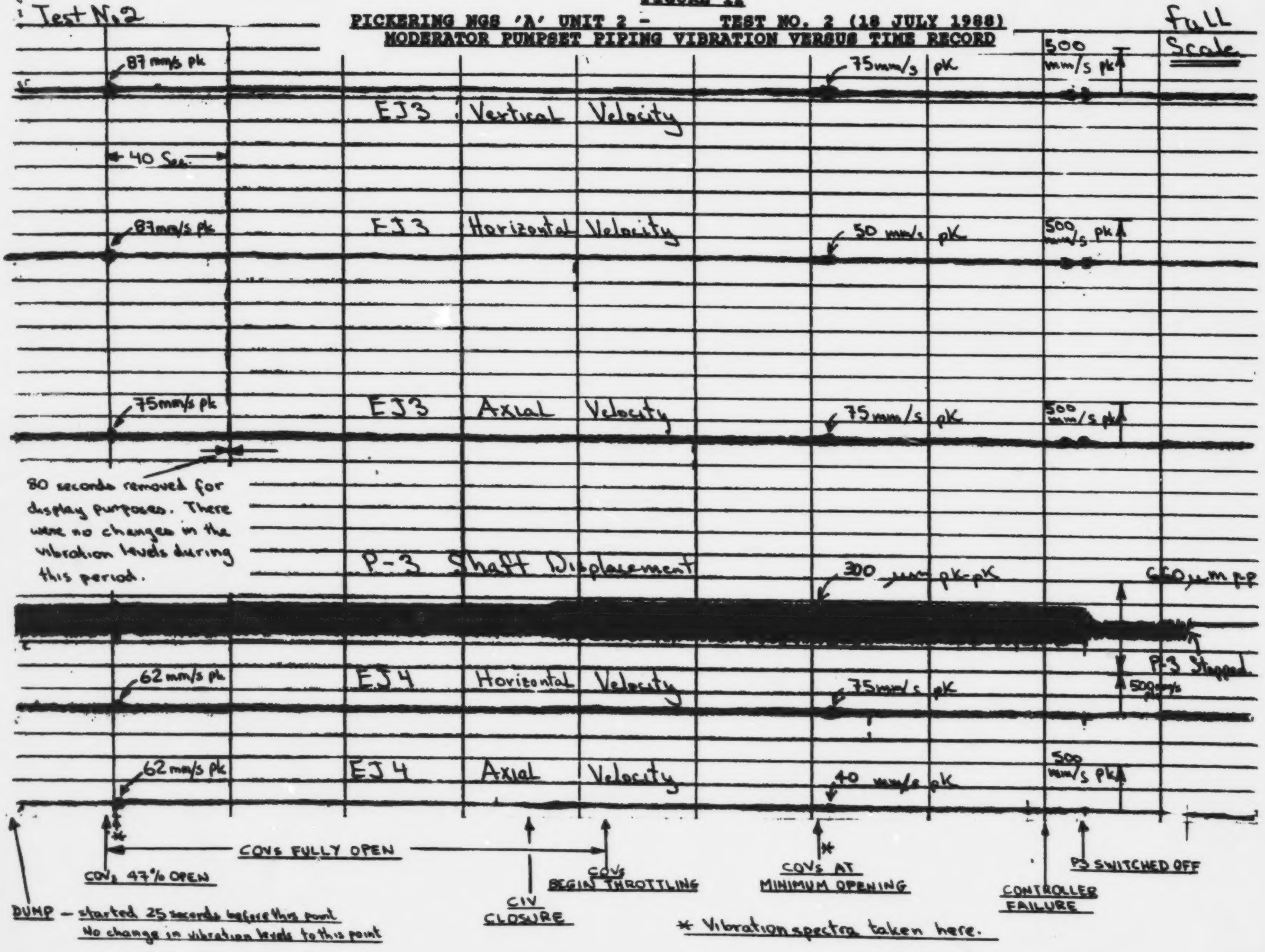


FIGURE 12

PICKERING NGS 'A' UNIT 2 - TEST NO. 2 (18 JULY 1988) MODERATOR PUMPSET PIPING VIBRATION VERSUS TIME RECORD



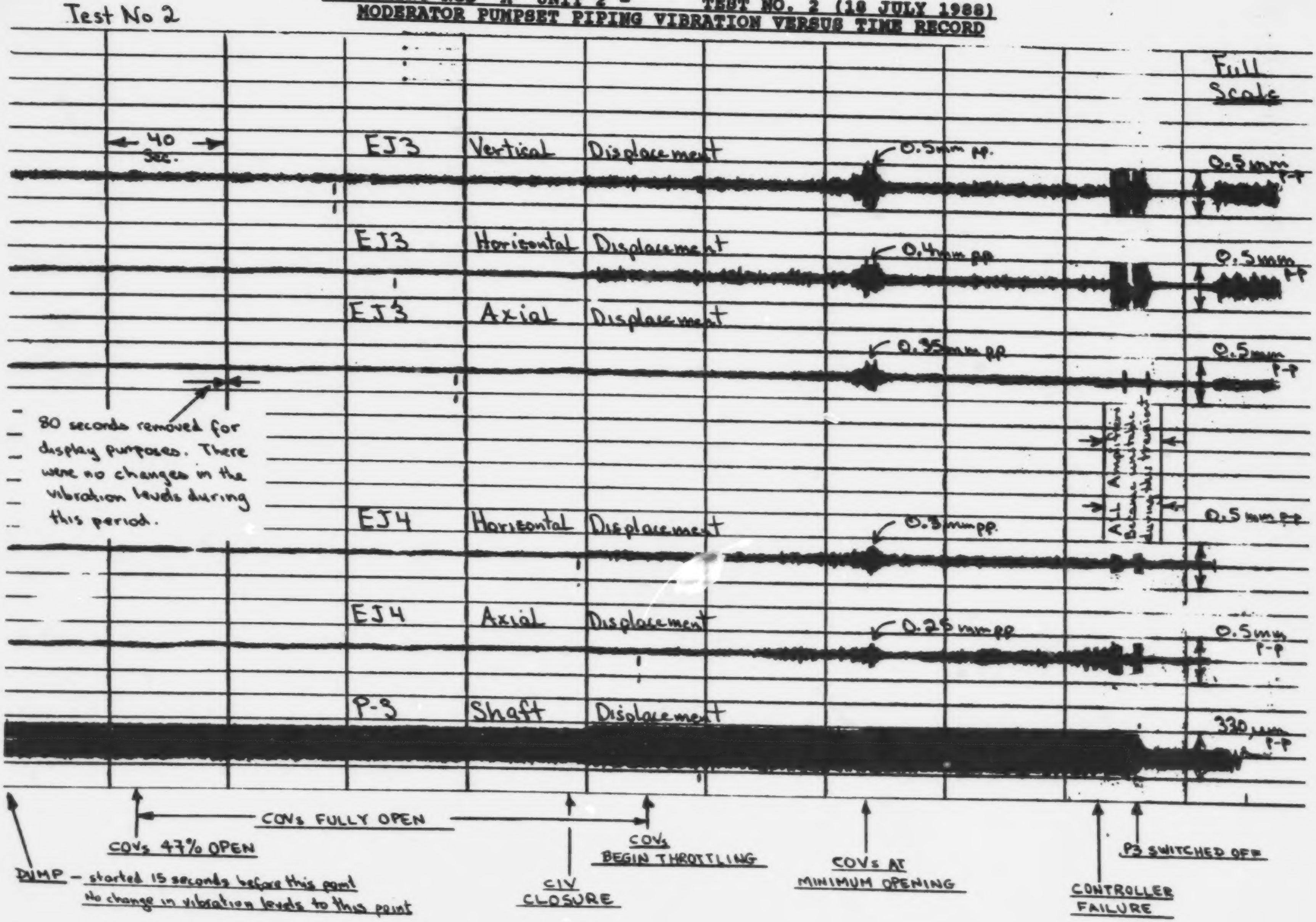
80 seconds removed for display purposes. There were no changes in the vibration levels during this period.

DUMP – started 25 seconds before this point
No change in vibration levels to this point

* Vibration spectra taken here.

FIGURE 13

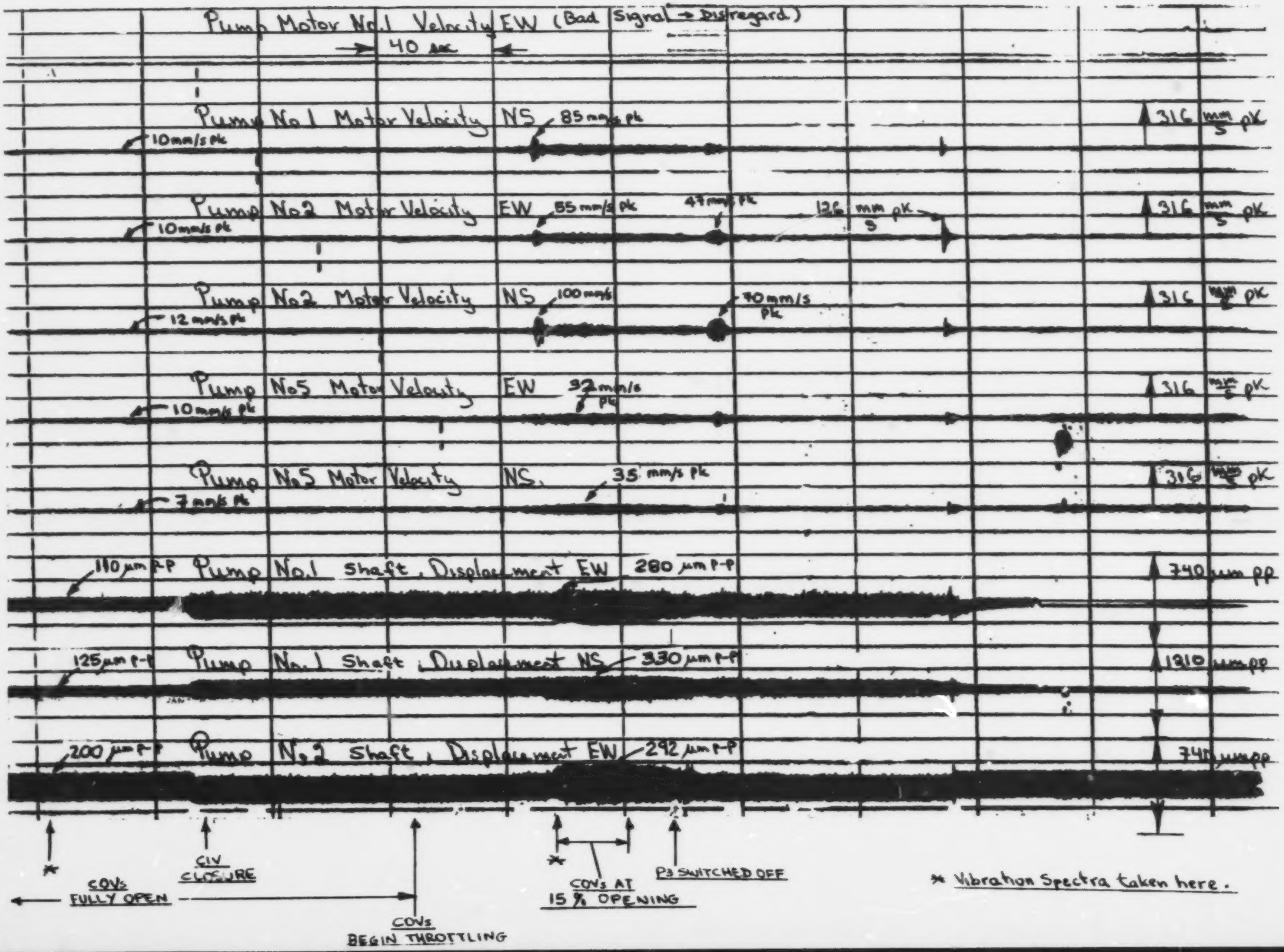
PICKERING NGS 'A' UNIT 2 - TEST NO. 2 (18 JULY 1988)
MODERATOR PUMPSET PIPING VIBRATION VERSUS TIME RECORD



Test No 3

FIGURE 14

PICKERING NGS 'A' UNIT 2 - TEST NO. 3 (19 JULY 1988)
MODERATOR PUMPSET VIBRATION VERSUS TIME RECORD



* Vibration Spectra taken here.

FIGURE 15

PICKERING NGS 'A' UNIT 2 - TEST NO. 3 (19 JULY 1988) MODERATOR PUMPSET VIBRATION VERSUS TIME RECORD

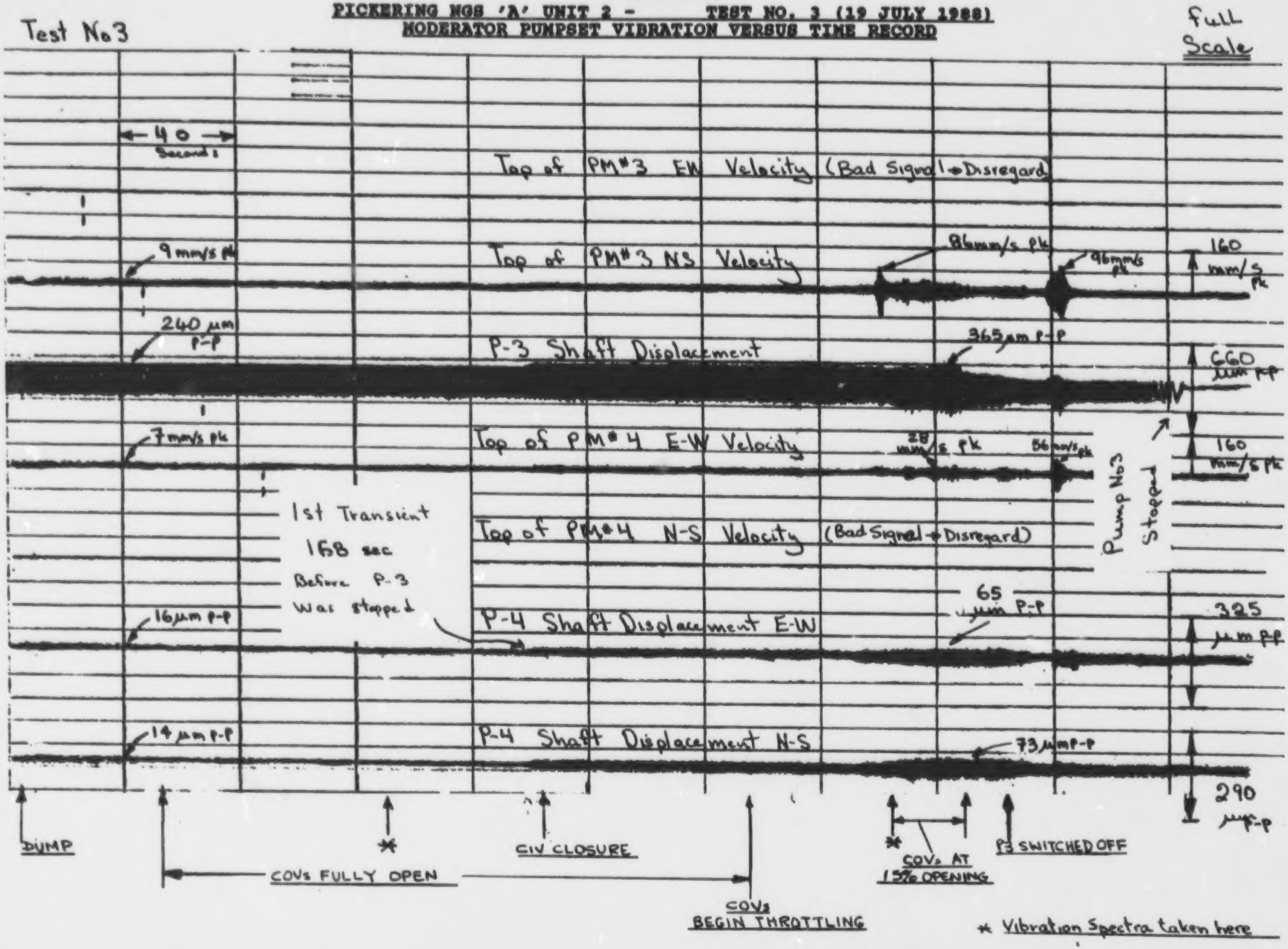
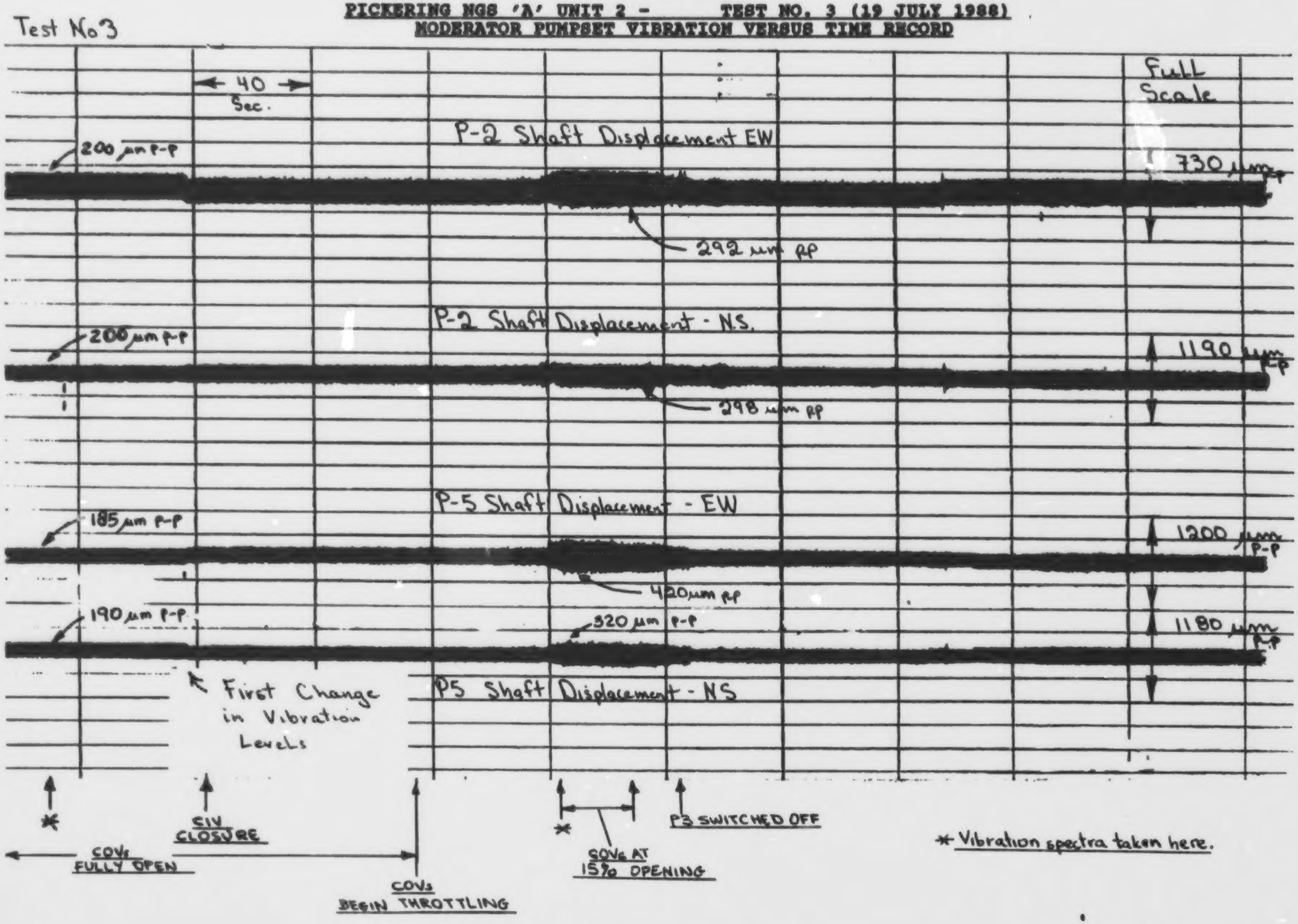


FIGURE 16

PICKERING NGS 'A' UNIT 2 - TEST NO. 3 (19 JULY 1988)
MODERATOR PUMPSET VIBRATION VERSUS TIME RECORD



* Vibration spectra taken here.

FIGURE 17

PICKERING NGS 'A' UNIT 2 - TEST NO. 3 (19 JULY 1988)
MODERATOR PUMPSET PIPING VIBRATION VERSUS TIME RECORD

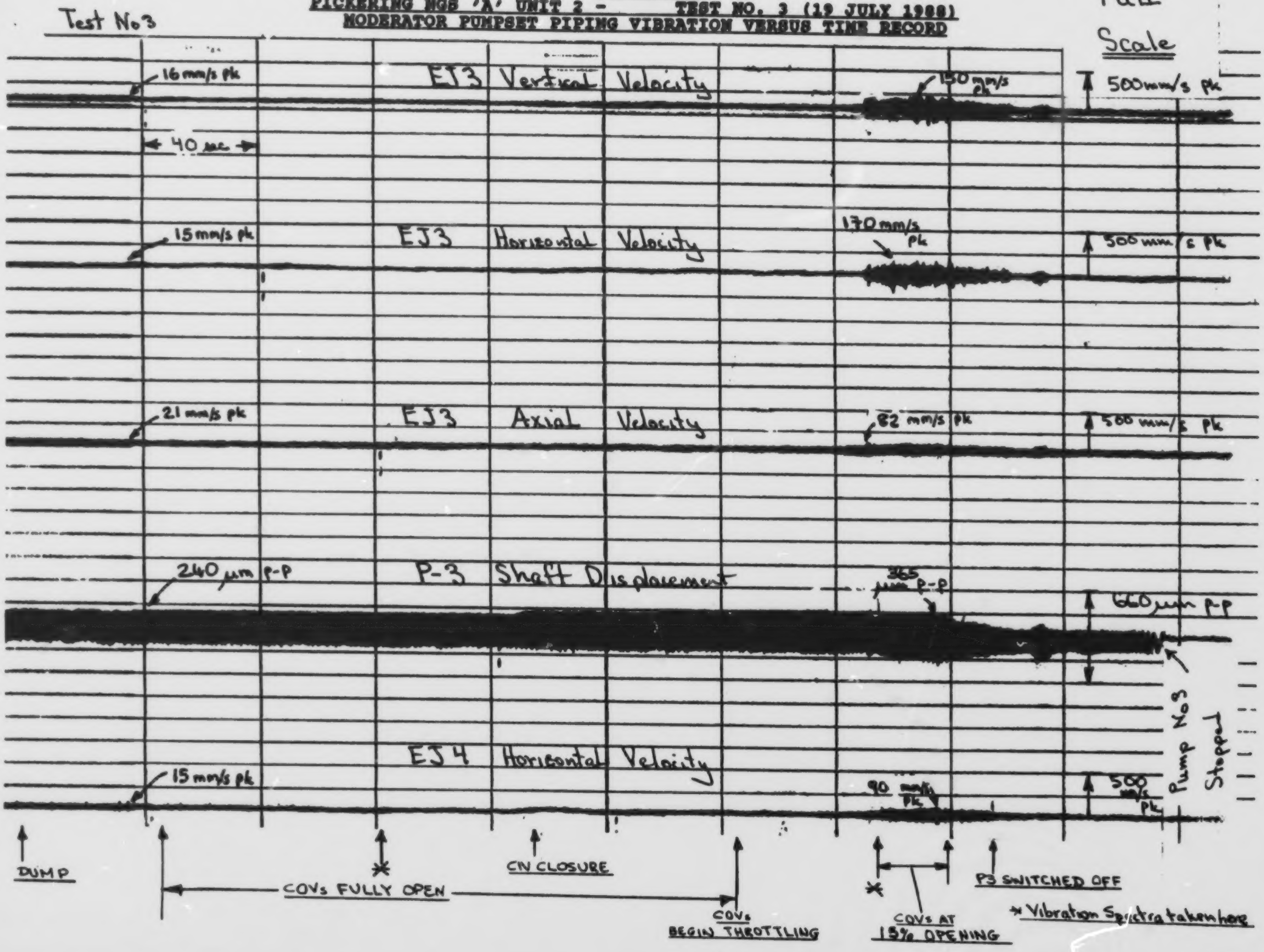


FIGURE 18

PICKERING NGS 'A' UNIT 2 - TEST NO. 3 (19 JULY 1988)
MODERATOR PUMPSET PIPING VIBRATION VERSUS TIME RECORD

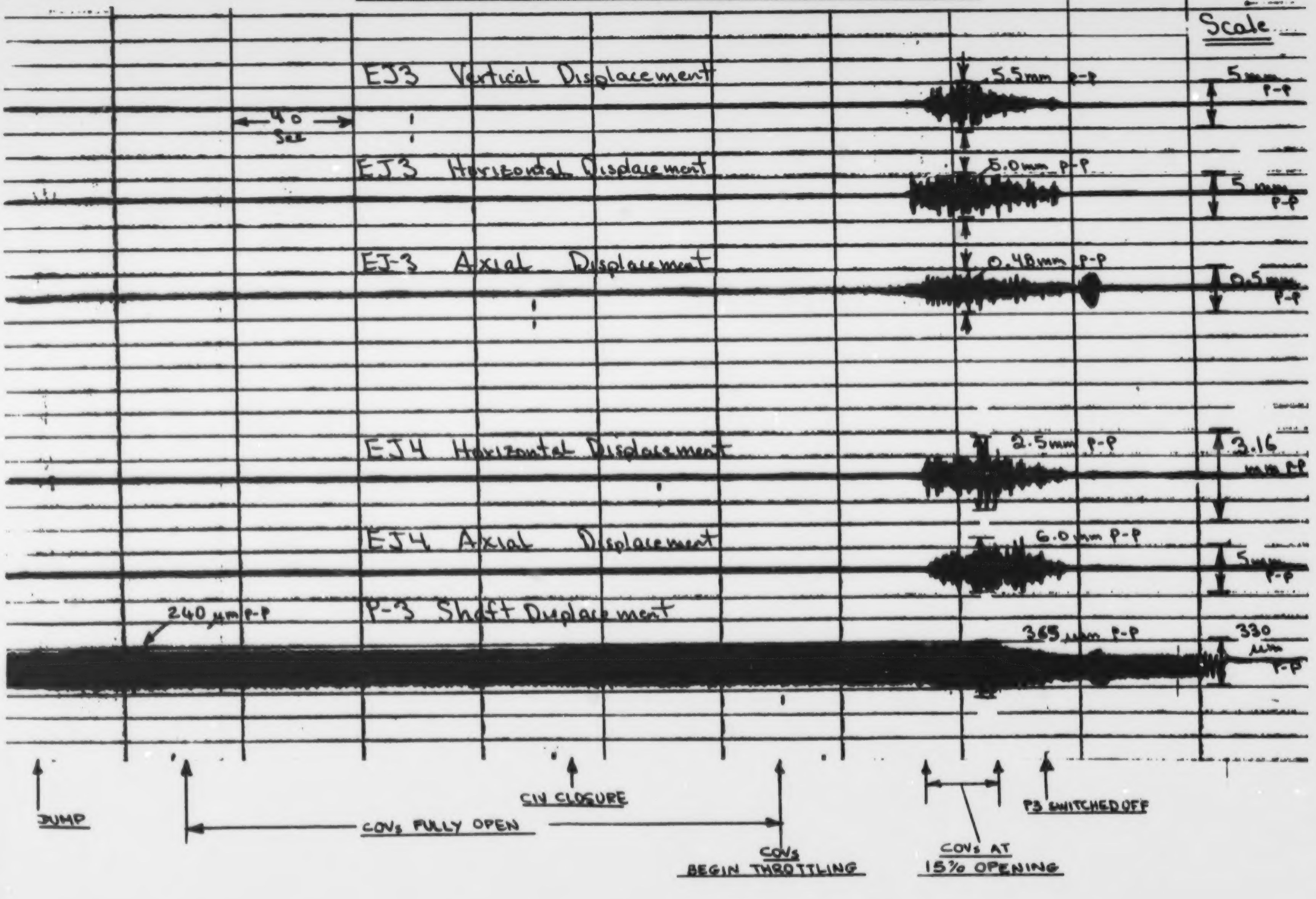


FIGURE 19

PICKERING NGS 'A' UNIT 2 - TEST NO. 1 (04 JULY 1988)
MODERATOR PUMPSET VIBRATION AND AVAILABLE NPSH VERSUS TIME

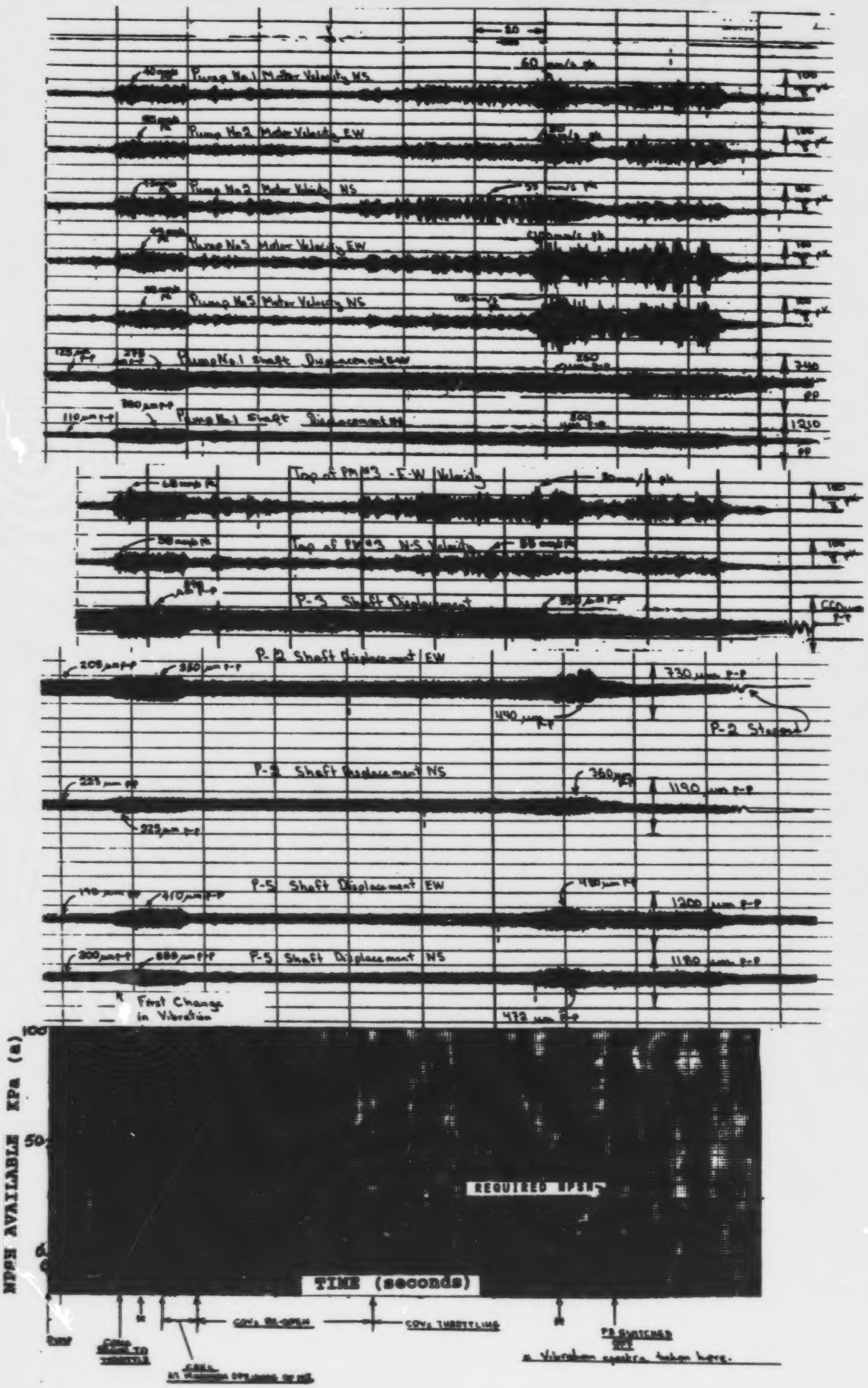


FIGURE 20

PICKERING NGS 'A' UNIT 2 - TEST NO. 2 (18 JULY 1988)

MODERATOR PUMPSET VIBRATION AND AVAILABLE NPSH VERSUS TIME

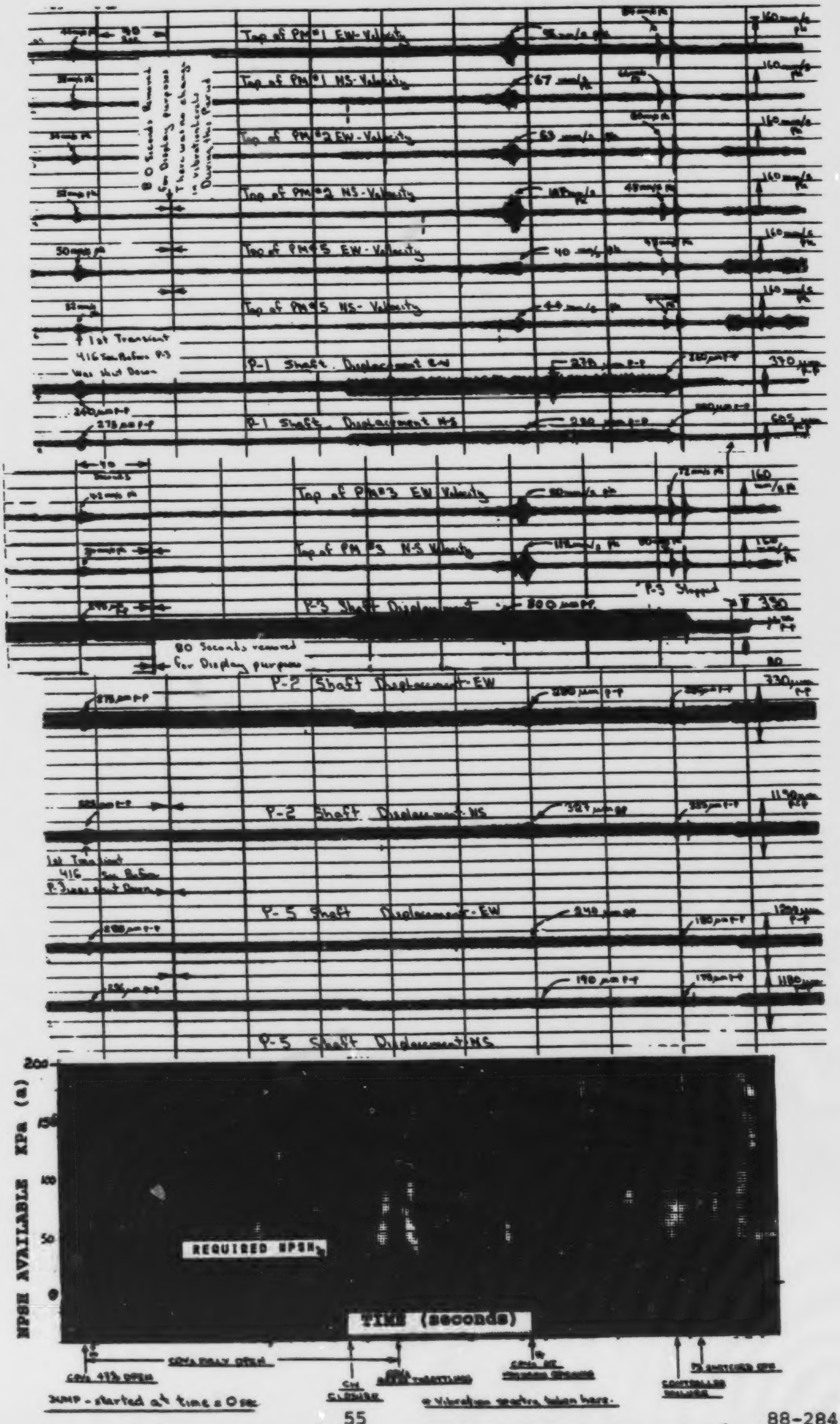
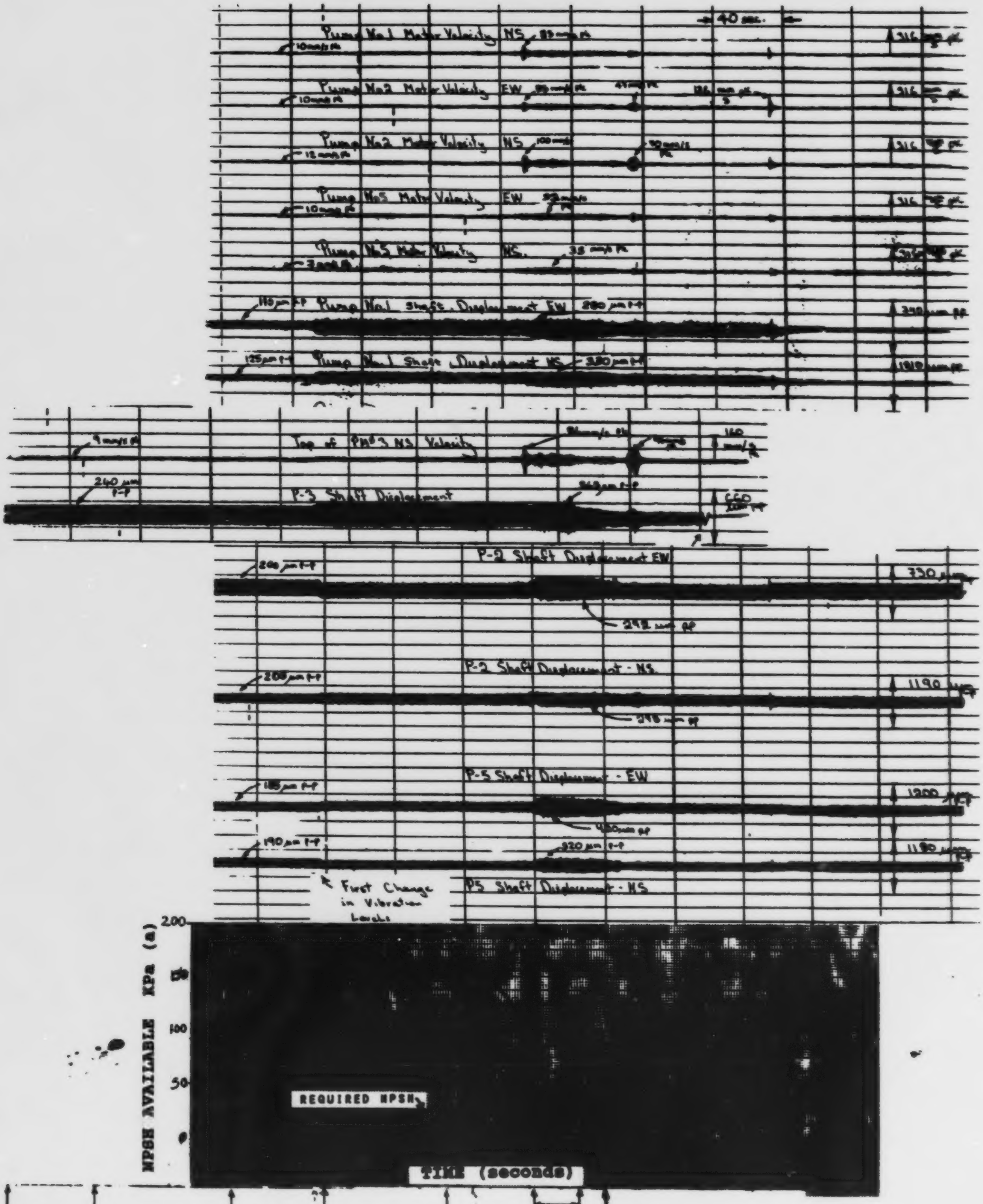
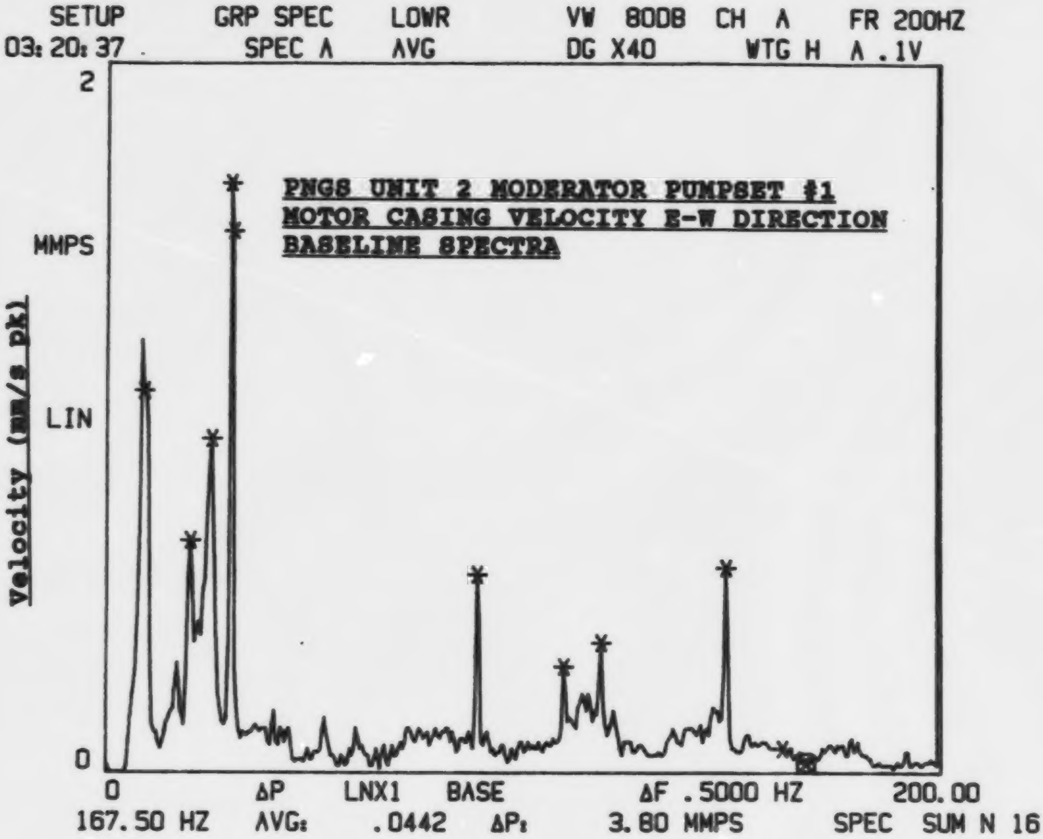


FIGURE 21

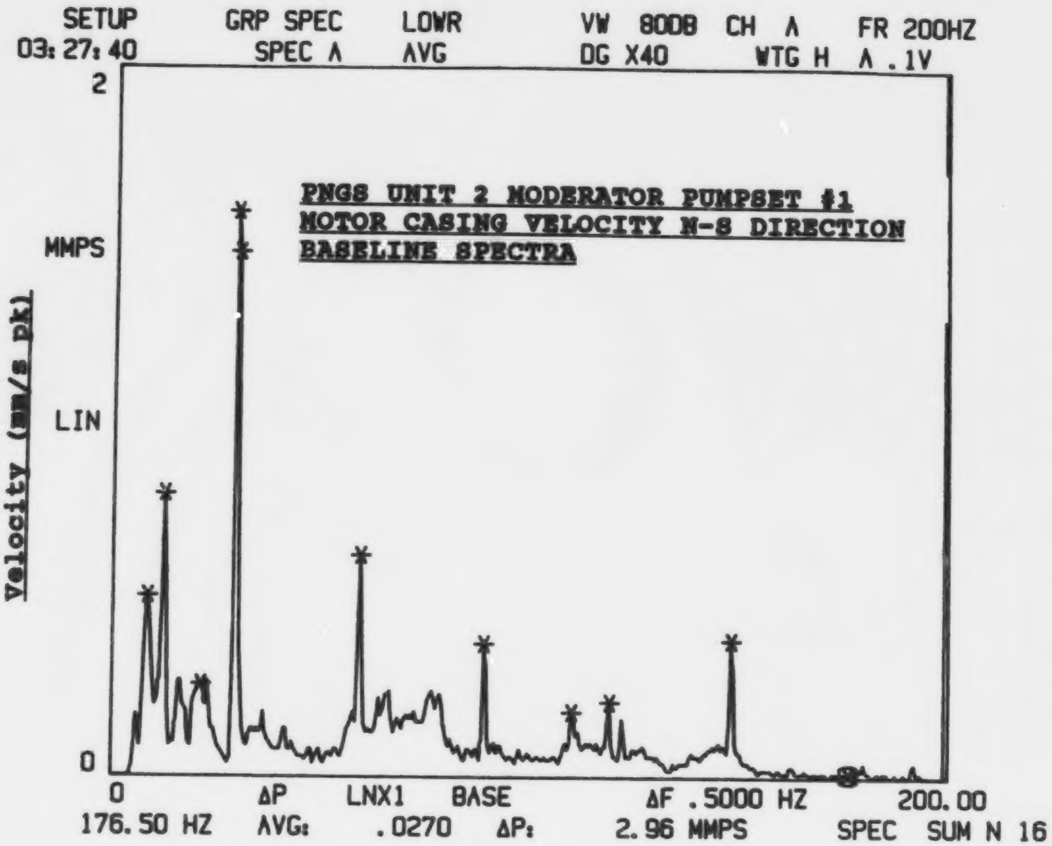
PICKERING NGS 'A' UNIT 2 - TEST NO. 3 (19 JULY 1988)
MODERATOR PUMPSET VIBRATION AND AVAILABLE NPSH VERSUS TIME





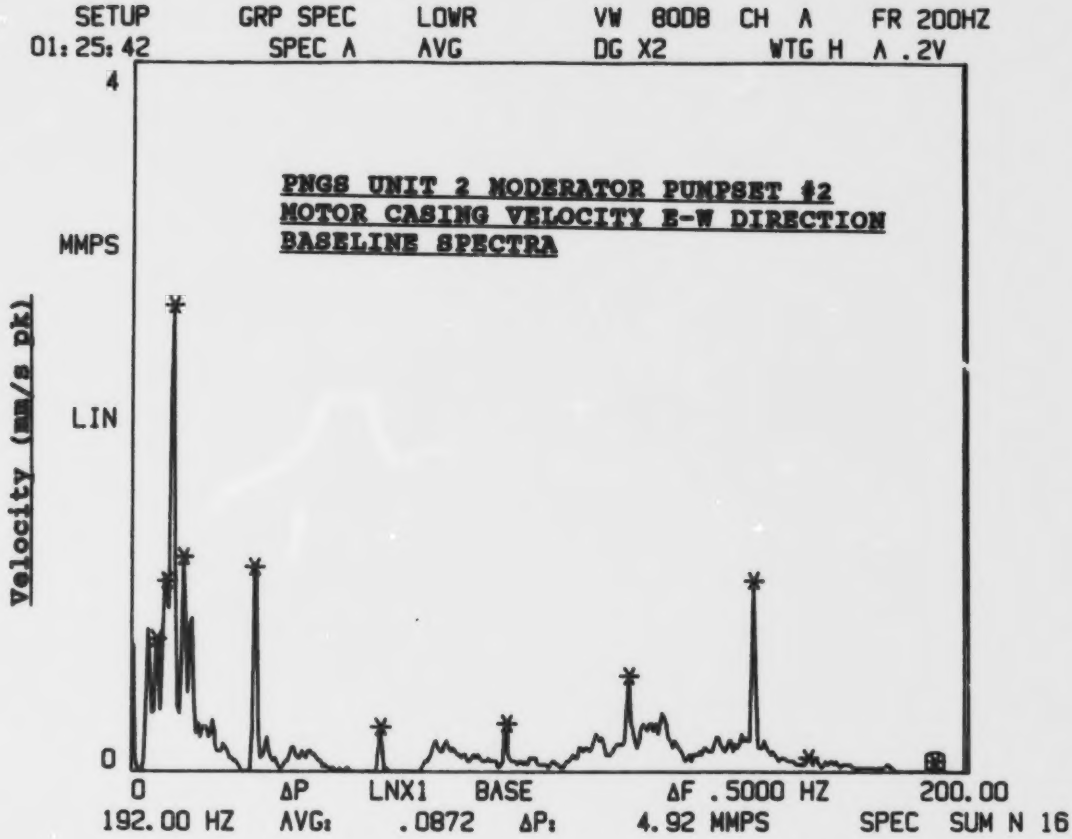
MARK	LIST X	Y
0	9.0000	1.09
1	20.000	.660
2	25.000	.957
3	29.500	1.67
4	30.000	1.53
5	89.000	.569
6	110.00	.305
7	119.00	.372
8	148.50	.584
9	162.00	.0824

FIGURE 22



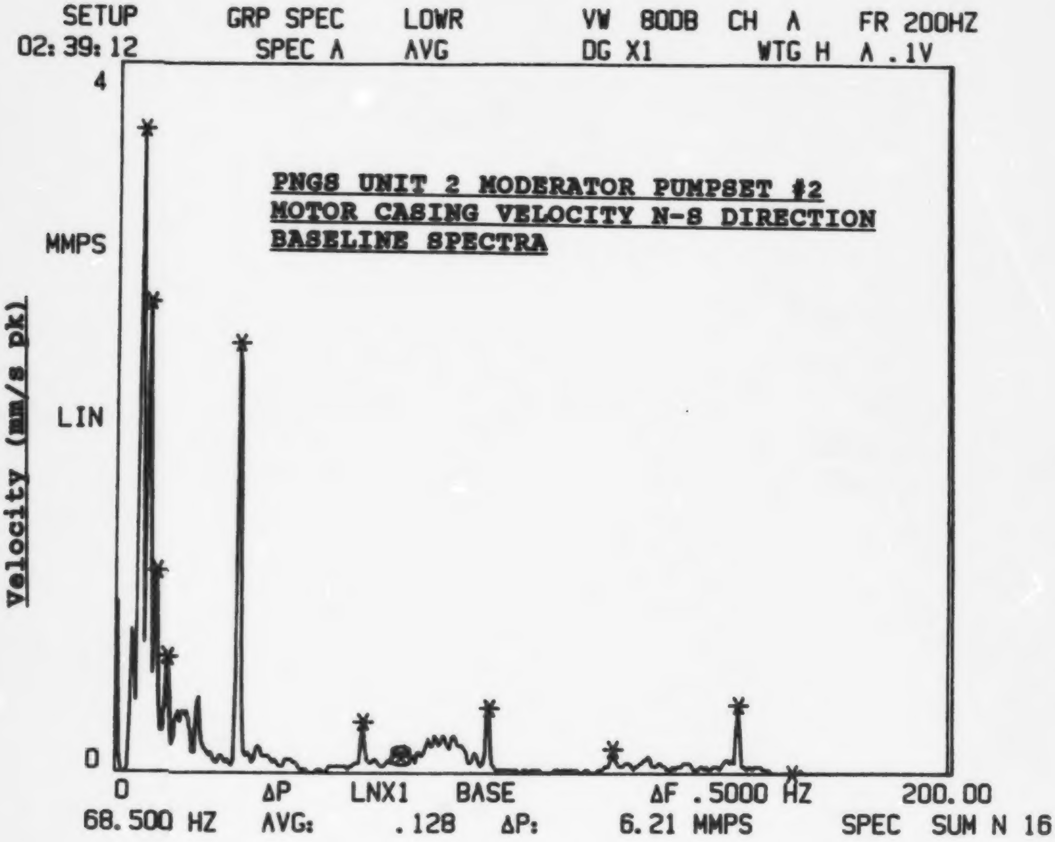
MARK	LIST X	Y
0	8.5000	.521
1	12.500	.804
2	21.500	.266
3	29.500	1.60
4	30.000	1.49
5	89.000	.379
6	110.00	.197
7	119.00	.225
8	148.50	.394
9	59.500	.636

FIGURE 23



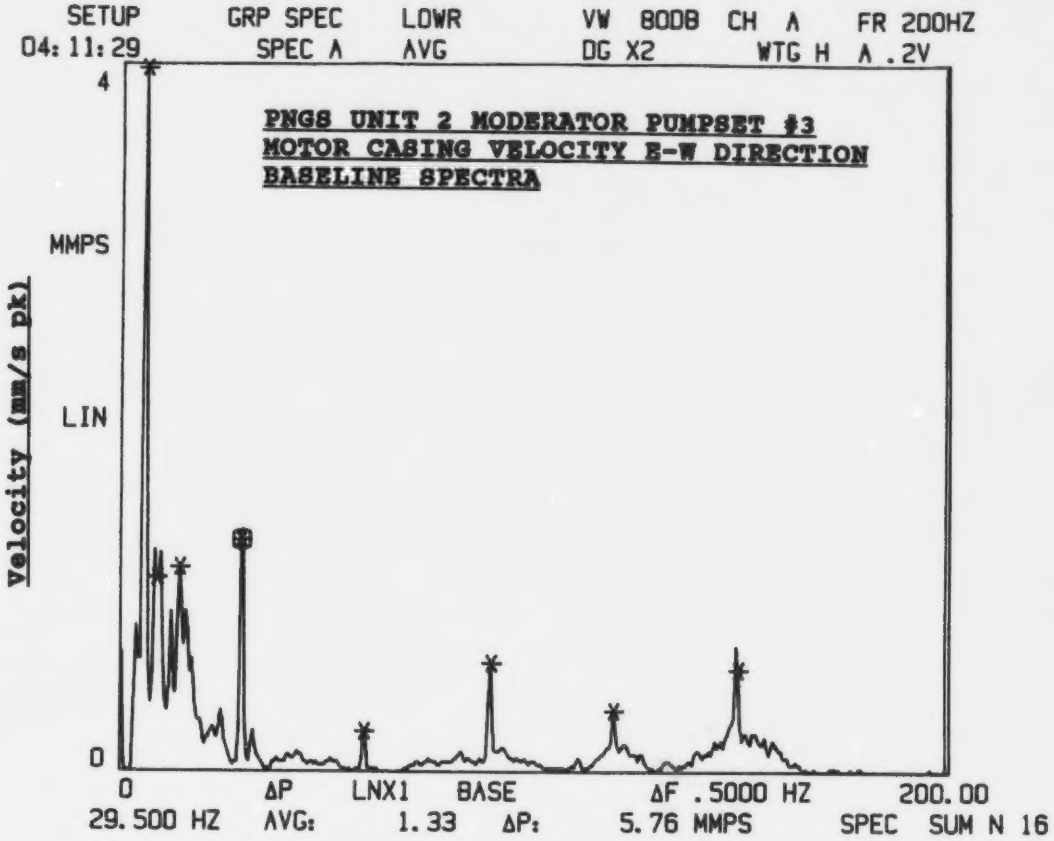
MARK LIST	X	Y
0	6.0000	.755
1	8.5000	1.10
2	10.000	2.67
3	12.500	1.23
4	29.500	1.16
5	59.500	.277
6	89.500	.292
7	119.00	.564
8	149.00	1.10
9	162.00	.0972

FIGURE 24



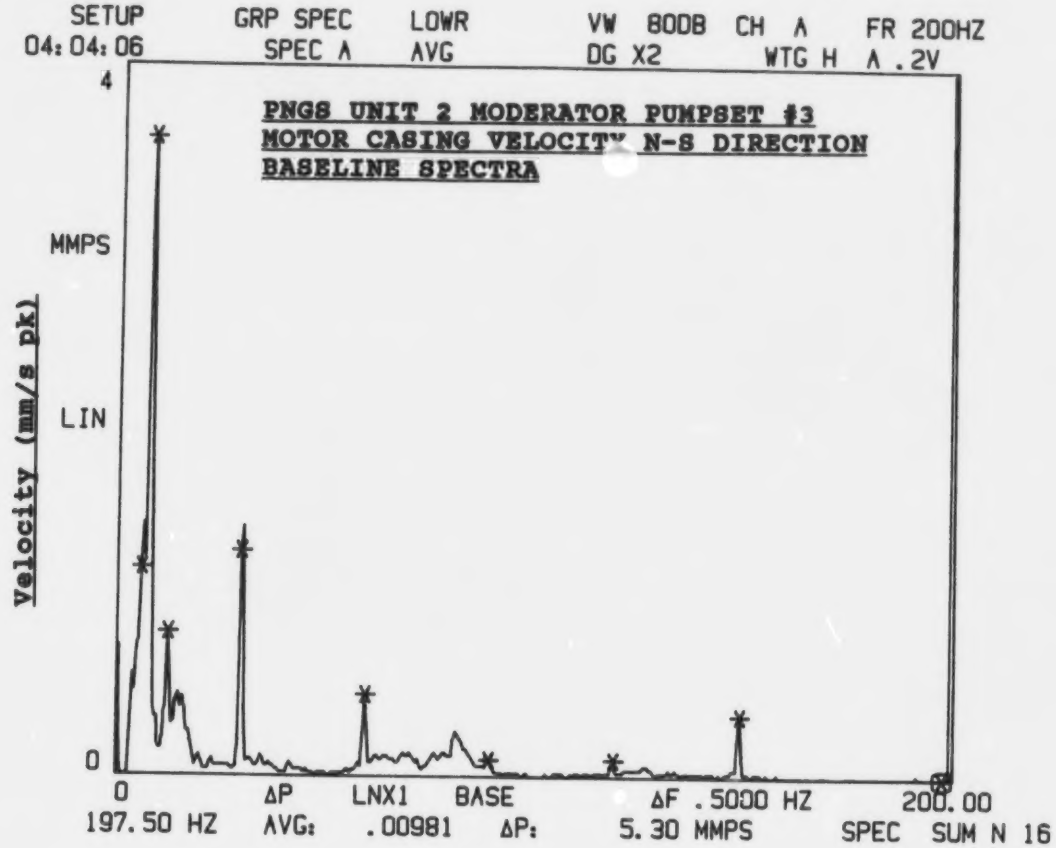
MARK	LIST X	Y
0	6.0000	3.69
1	8.0000	2.68
2	10.000	1.14
3	12.500	.676
4	29.500	2.43
5	59.500	.316
6	89.500	.386
7	119.00	.160
8	149.00	.411
9	162.00	.0275

FIGURE 25



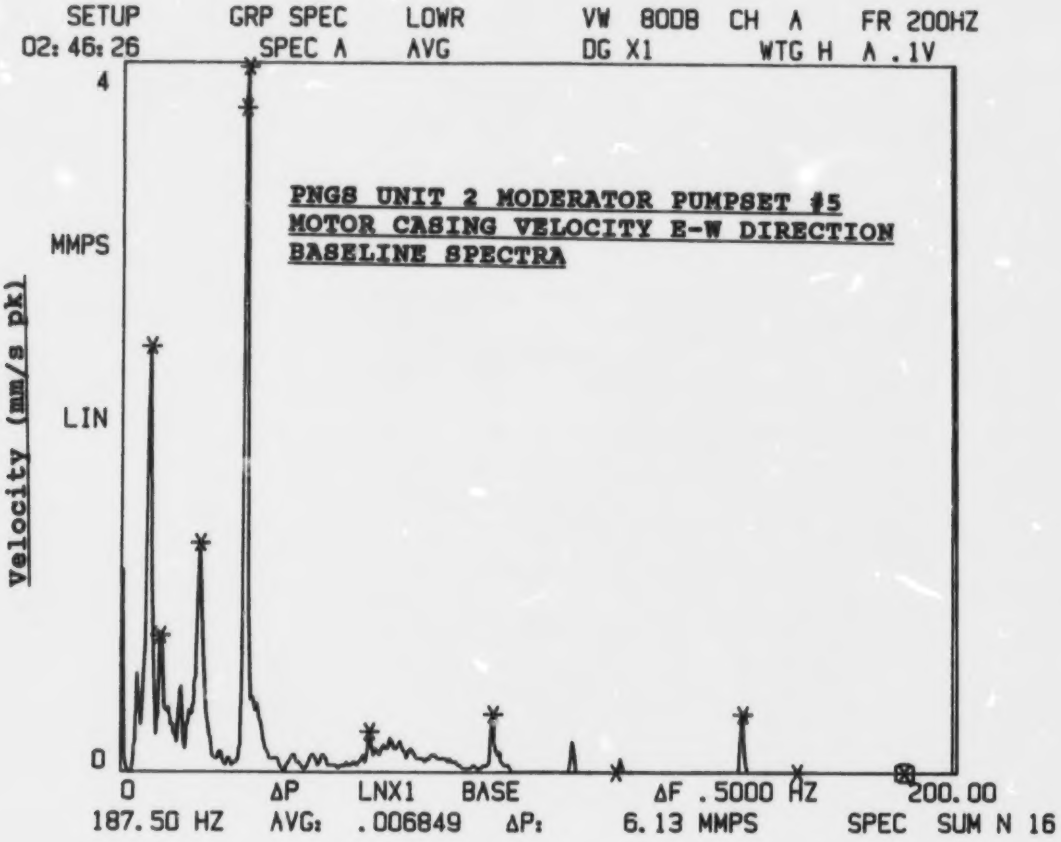
MARK	LIST X	Y
0	6.0000	4.19
1	9.0000	1.12
2	14.500	1.16
3	29.500	1.33
4	59.500	.259
5	89.500	.632
6	119.00	.371
7	149.00	.584
8	---	---
9	---	---

FIGURE 26



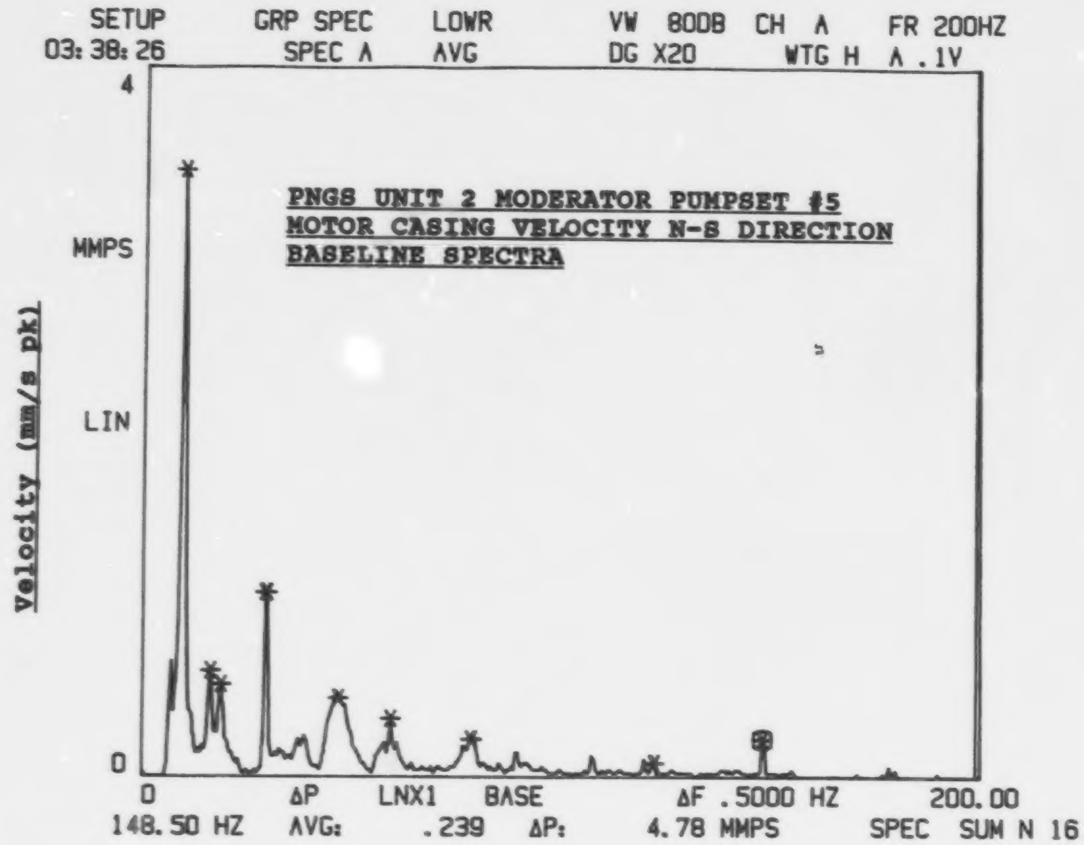
```
MARK LIST X      Y
0      6.0000    1.20
1      8.0000    3.63
2      12.500    .814
3      29.500    1.28
4      59.500    .478
5      89.500    .117
6      119.00    .128
7      149.00    .371
8       ---      ---
9       ---      ---
```

FIGURE 27



MARK	LIST X	Y
0	7.0000	2.42
1	9.5000	.783
2	19.000	1.30
3	29.500	3.77
4	30.000	3.98
5	59.500	.248
6	89.500	.346
7	119.00	.0309
8	149.00	.339
9	162.00	.0111

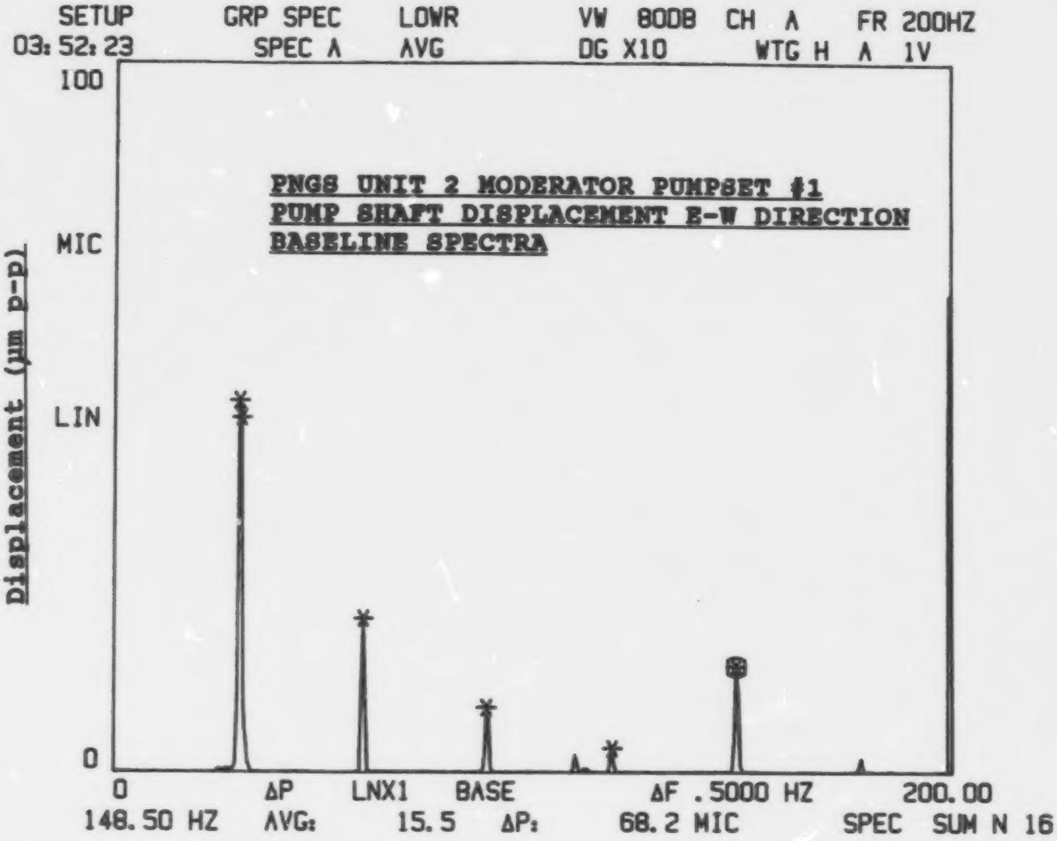
FIGURE 28



PNGS UNIT 2 MODERATOR PUMPSET #5
MOTOR CASING VELOCITY N-S DIRECTION
BASELINE SPECTRA

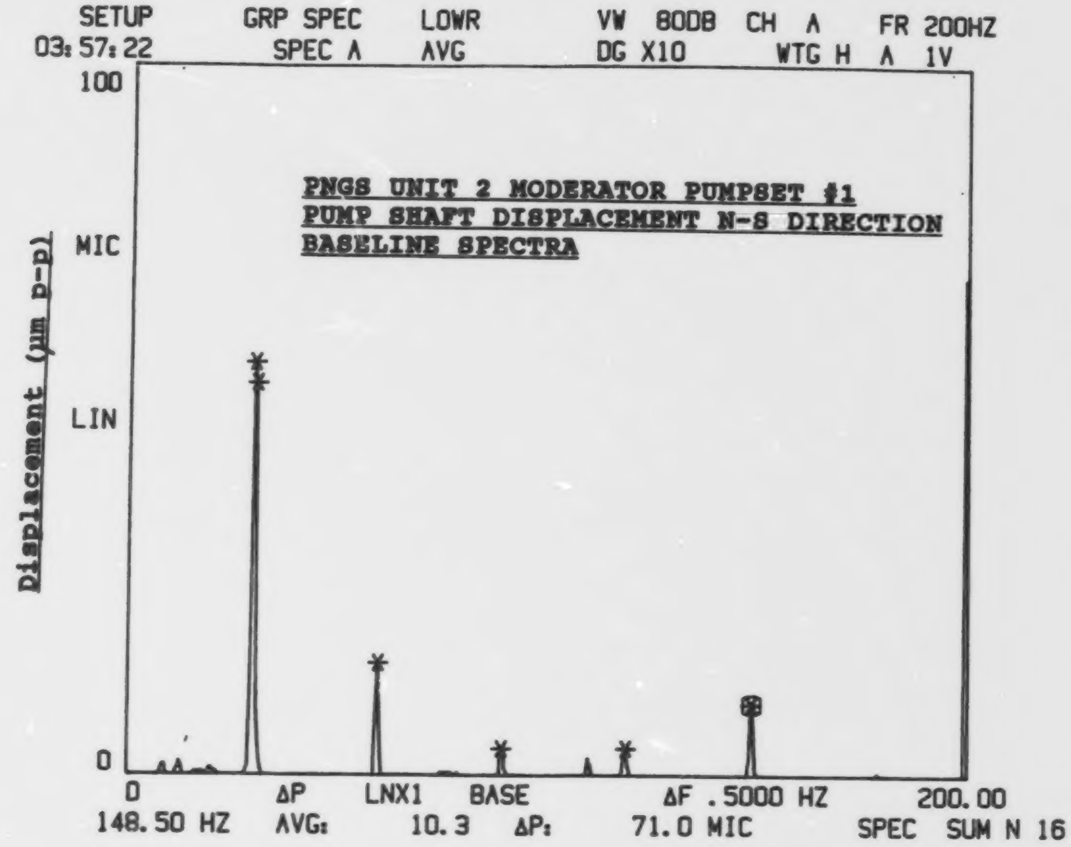
MARK	LIST X	Y
0	9.5000	3.45
1	16.500	.613
2	19.000	.538
3	29.500	1.07
4	30.000	1.07
5	47.000	.465
6	59.500	.346
7	78.500	.235
8	122.50	.0945
9	148.50	.239

FIGURE 29



MARK	LIST X	Y
0	29.500	53.2
1	30.000	50.5
2	59.500	22.6
3	89.000	9.57
4	119.00	3.92
5	148.50	15.5
6	---	---
7	---	---
8	---	---
9	---	---

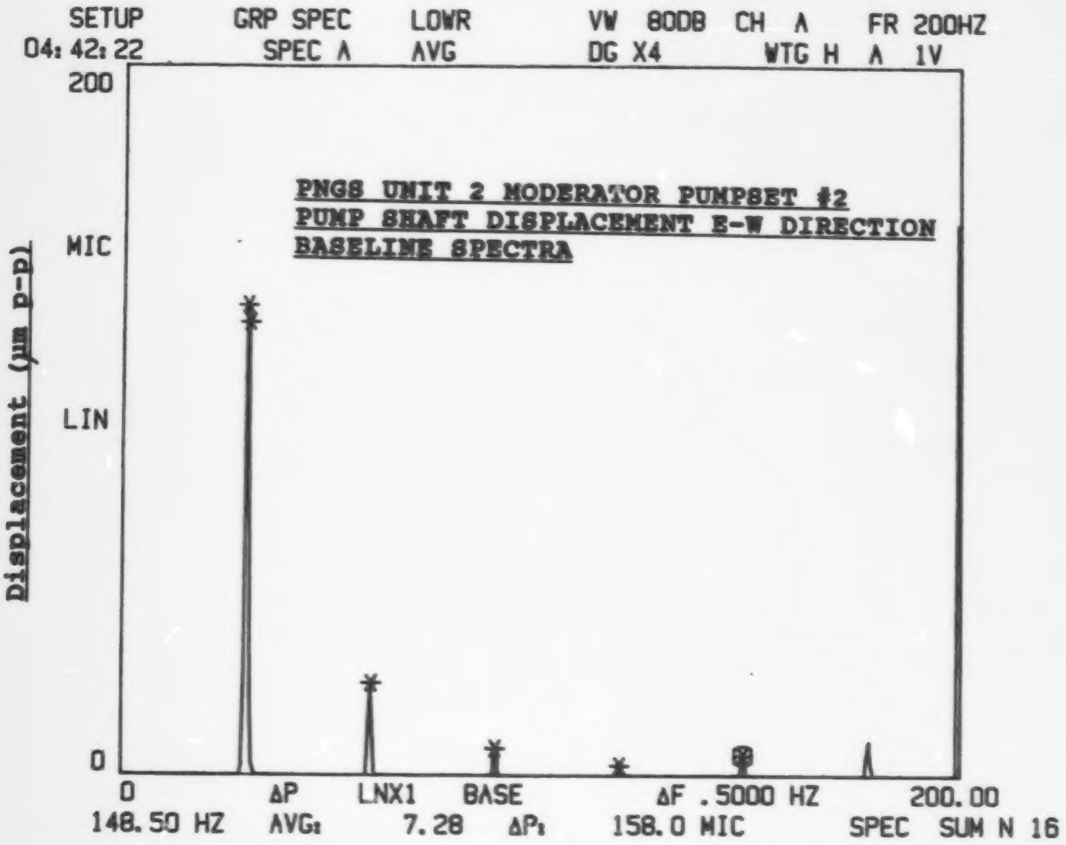
FIGURE 30



PNGS UNIT 2 MODERATOR PUMPSET #1
PUMP SHAFT DISPLACEMENT N-S DIRECTION
BASELINE SPECTRA

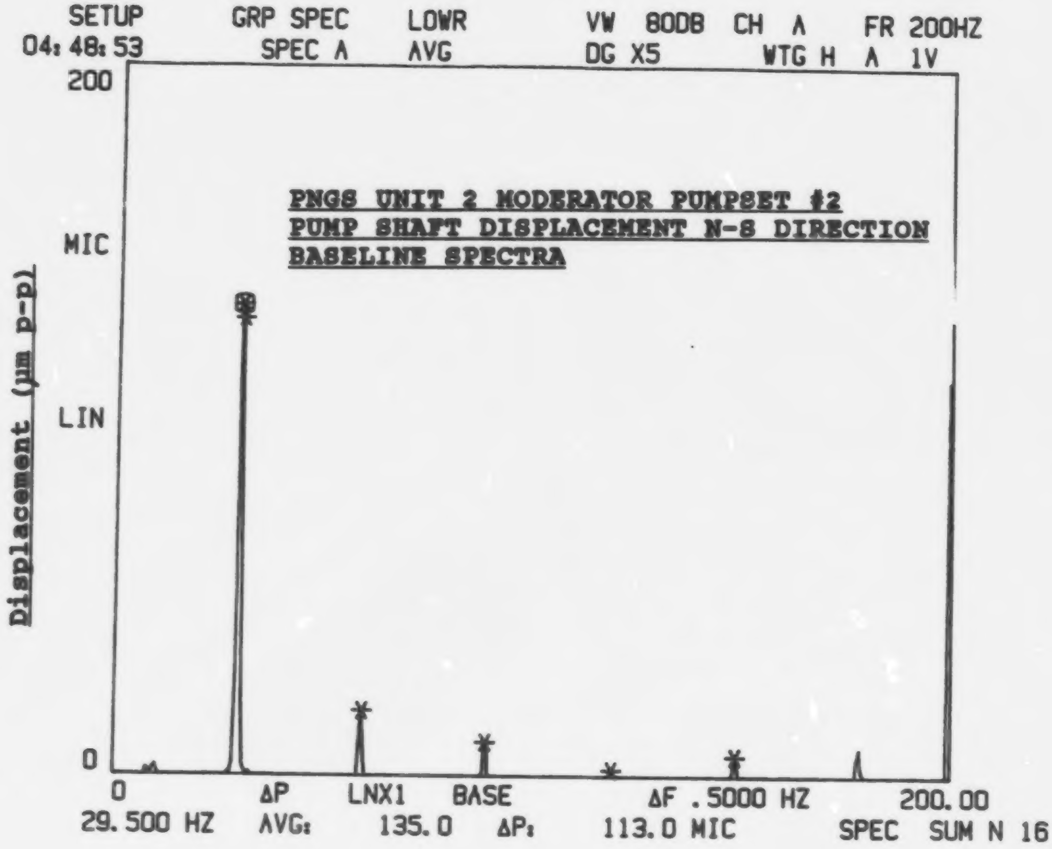
MARK	LIST X	Y
0	29.500	58.7
1	30.000	55.9
2	59.500	16.1
3	89.000	4.48
4	119.00	4.71
5	148.50	10.3
6	---	---
7	---	---
8	---	---
9	---	---

FIGURE 31



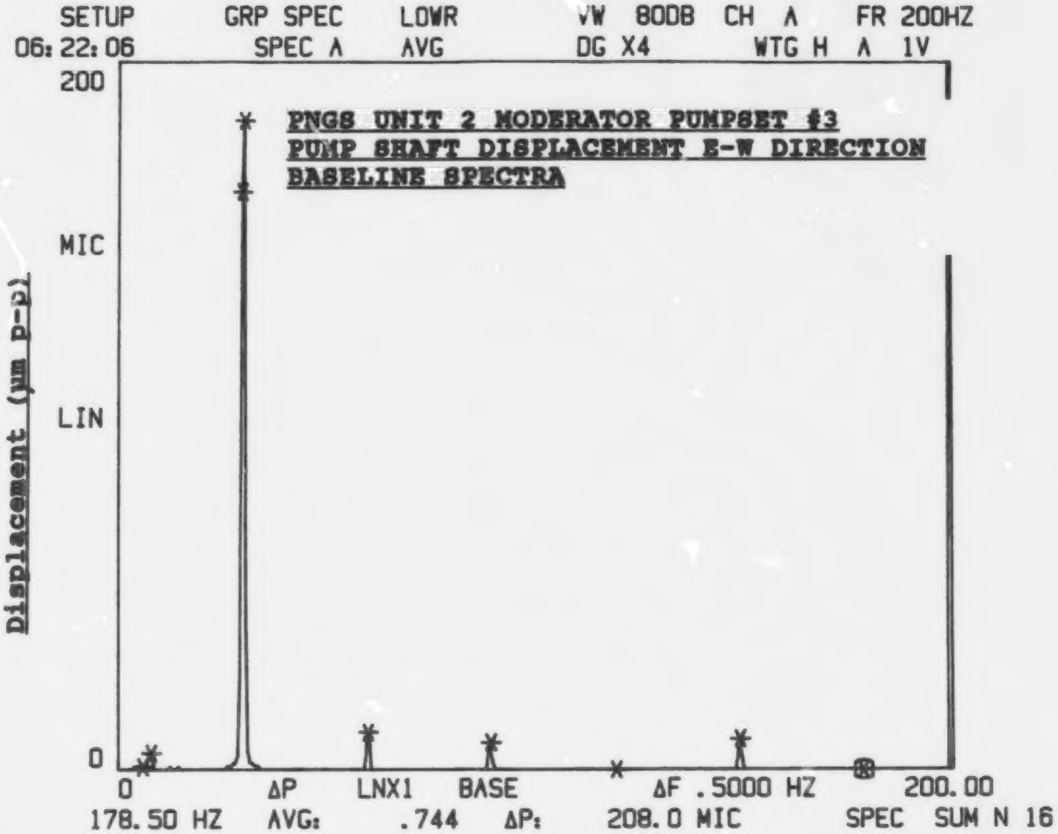
```
MARK LIST X      Y
0     29.500   134.0
1     30.000   129.0
2     59.500    27.1
3     89.000    9.34
4     119.00    4.61
5     148.50    7.28
6      ---      ---
7      ---      ---
8      ---      ---
9      ---      ---
```

FIGURE 32



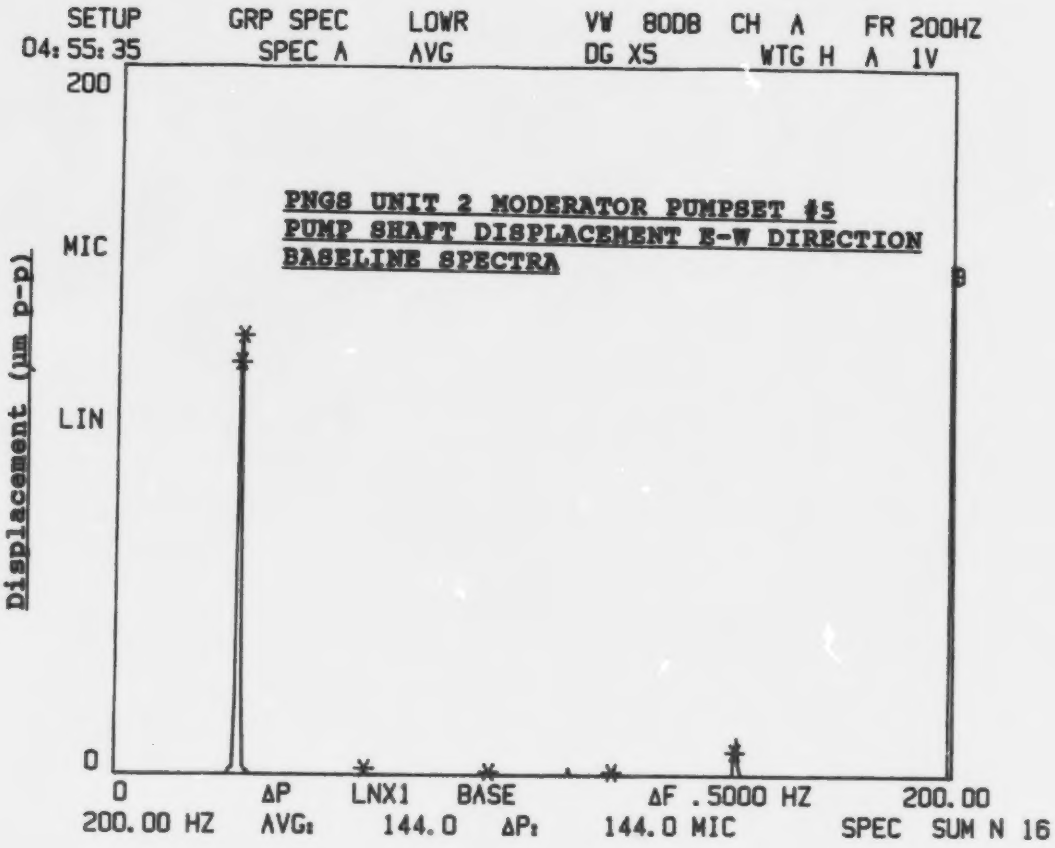
```
MARK LIST X       Y
0     29.500    135.0
1     30.000    123.0
2     59.500     19.4
3     89.000     10.8
4     119.00     3.01
5     148.50     7.19
6      ---       ---
7      ---       ---
8      ---       ---
9      ---       ---
```

FIGURE 33



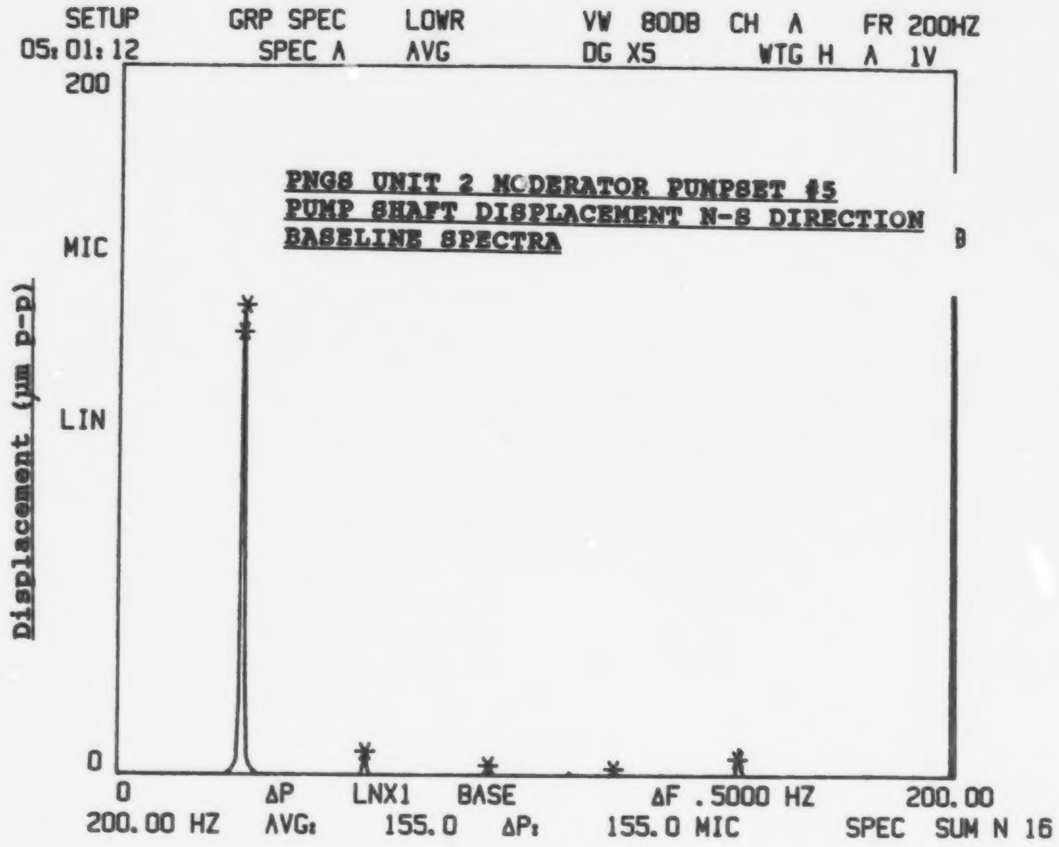
MARK	LIST X	Y
0	6.0000	2.48
1	8.0000	5.80
2	29.500	164.0
3	30.000	185.0
4	59.500	11.6
5	89.500	8.72
6	119.50	1.39
7	149.00	10.3
8	149.00	10.3
9	---	---

FIGURE 34



```
MARK LIST X        Y
0       29.500    116.9
1       30.000    125.0
2       59.500      3.39
3       89.000      2.21
4      119.00       2.71
5      148.50       8.36
6        ---       ---
7        ---       ---
8        ---       ---
9        ---       ---
```

FIGURE 35



MARK	LIST X	Y
0	29.500	126.0
1	30.000	135.0
2	59.500	7.84
3	89.000	4.03
4	119.00	3.00
5	148.50	6.21
6	---	---
7	---	---
8	---	---
9	---	---

FIGURE 36

PNGS Unit 2 - ECIS Test #1 Moderator Pumpset Vibration

SIGNAL : Pumpset #1 - Motor Casing Vel N-S
PROCESS CONDITION : Dump Test Loc 1

PEAK NO.	FREQUENCY	AMPLITUDE
1	6.0	8.63
2	149.1	4.81
3	30.1	3.67
4	64.9	2.15
5	78.2	1.84
6	73.4	1.59
7	119.1	1.24
8	89.0	1.15
9	58.9	1.13
10	328.3	0.93

SCALE: Linear DATE: 04-07-88

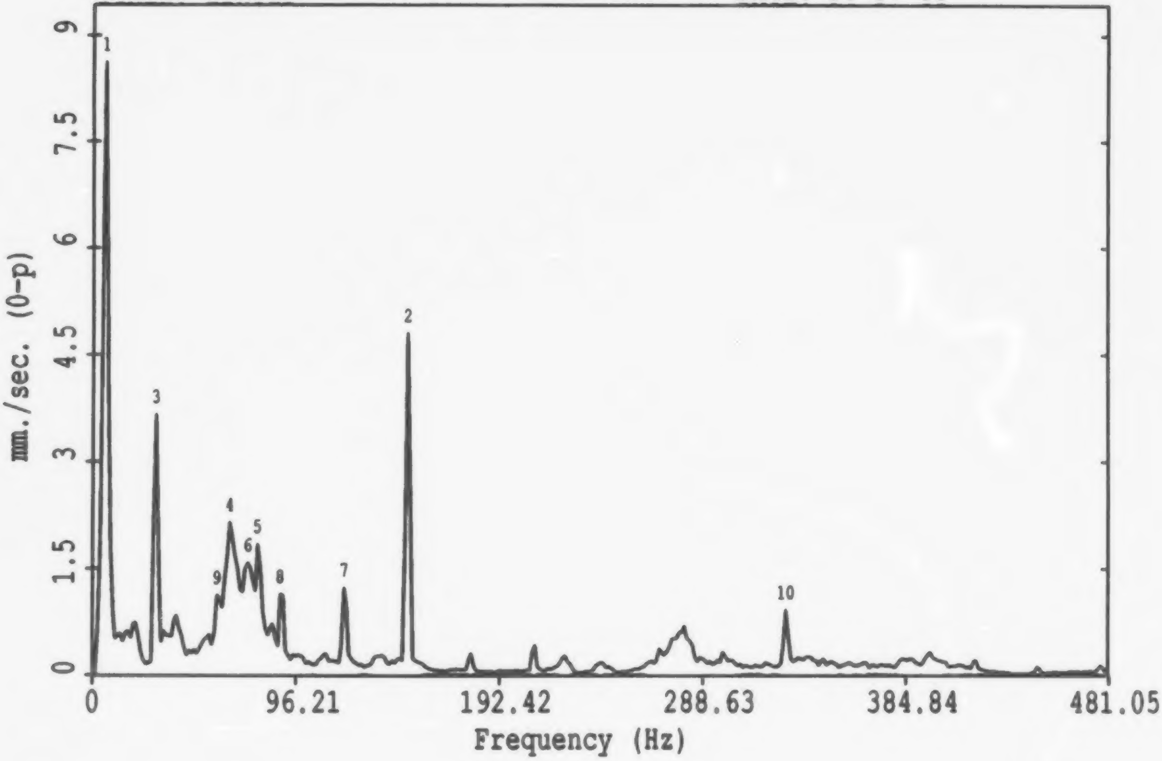


FIGURE 37

PNGS Unit 2 - ECIS Test #1 Moderator Pumpset Vibration

SIGNAL : Pumpset #2 - Motor Casing Vel E-W
PROCESS CONDITION : Dump Test Loc 1

PEAK NO.	FREQUENCY	AMPLITUDE
1	9.6	6.42
2	149.1	4.69
3	6.0	3.35
4	119.1	1.76
5	298.3	1.64
6	268.2	1.56
7	13.2	1.21
8	38.5	1.00
9	179.2	0.90
10	89.0	0.88

SCALE: Linear

DATE: 04-07-88

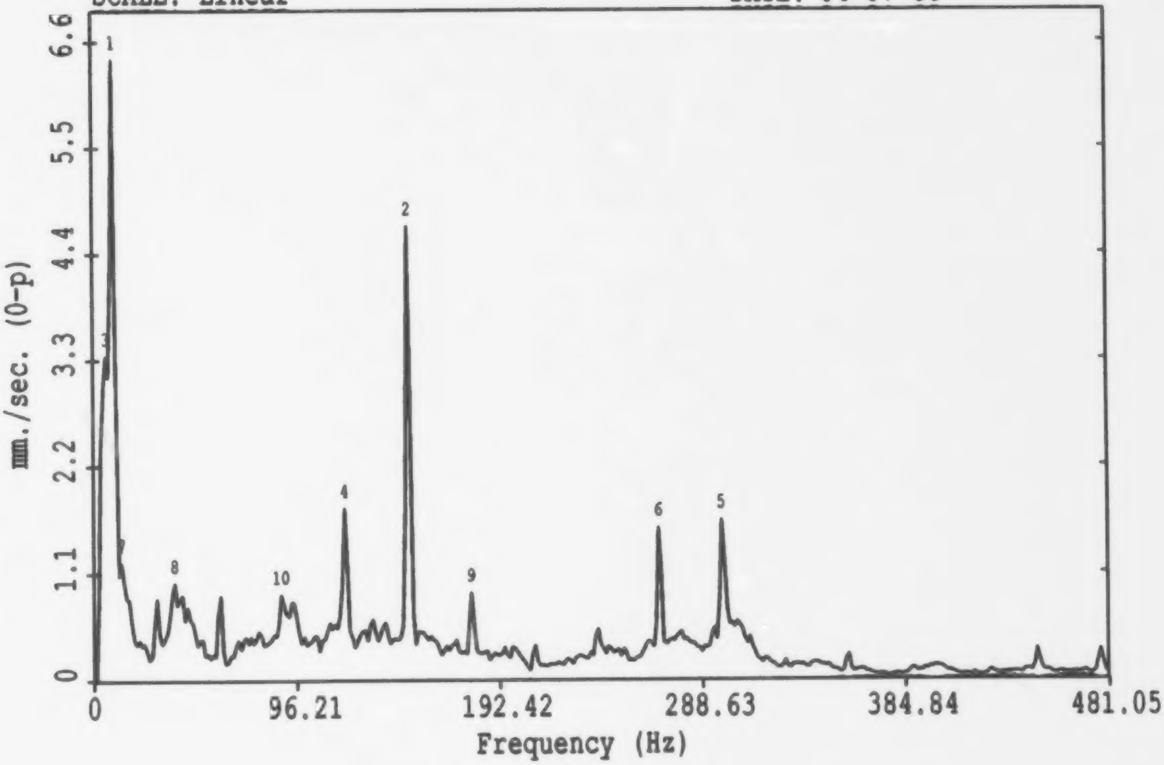


FIGURE 38

PNGS Unit 2 - ECIS Test #1 Moderator Pumpset Vibration

SIGNAL : Pumpset #2 - Motor Casing Vel N-S
PROCESS CONDITION : Dump Test Loc 1

PEAK NO.	FREQUENCY	AMPLITUDE
1	6.0	10.40
2	30.1	4.25
3	149.1	3.57
4	74.6	2.19
5	298.3	2.03
6	60.1	1.96
7	78.2	1.70
8	68.6	1.67
9	64.9	1.17
10	83.0	1.09

SCALE: Linear DATE: 04-07-88

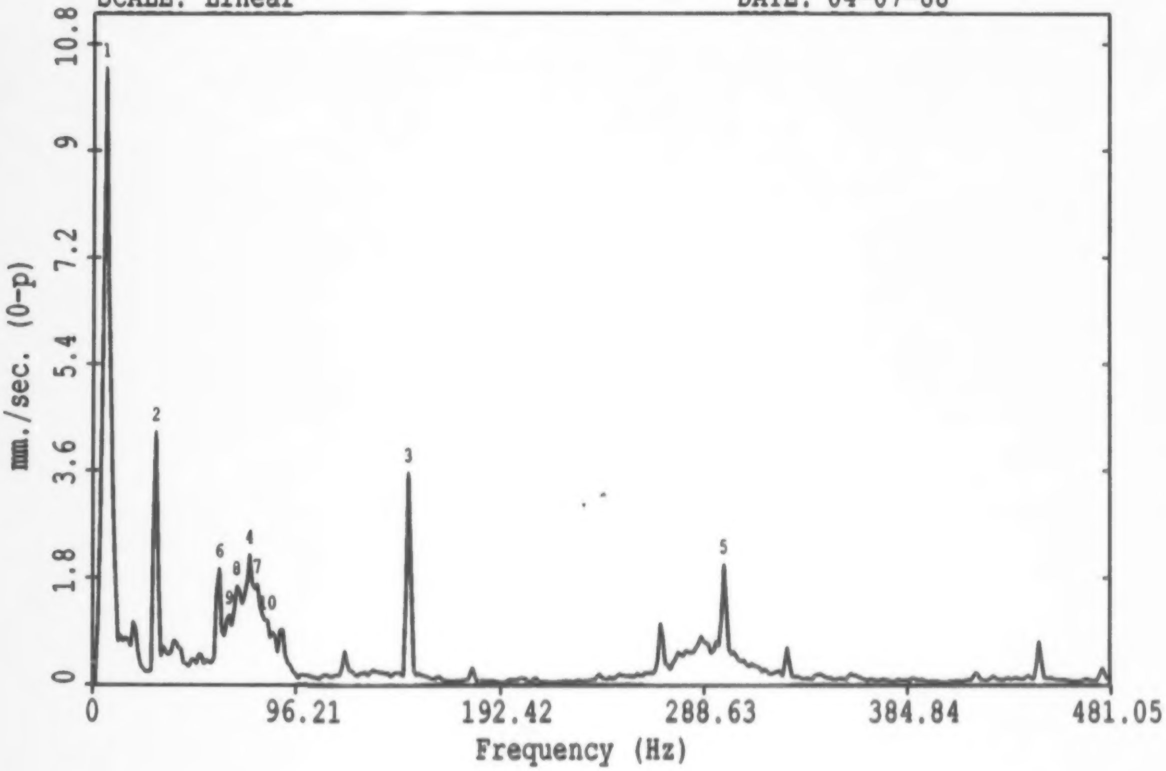


FIGURE 39

PNGS Unit 2 - ECIS Test #1 Moderator Pumpset Vibration

SIGNAL : Pumpset #3 - Motor Casing Velocity E-W
PROCESS CONDITION : Dump Test Loc 1

PEAK NO.	FREQUENCY	AMPLITUDE
1	149.1	14.17
2	6.0	9.99
3	30.1	4.27
4	9.6	3.76
5	90.2	2.86
6	119.1	2.79
7	15.6	2.21
8	153.9	1.95
9	145.5	1.35
10	157.5	1.34

SCALE: Linear

DATE: 04-07-88

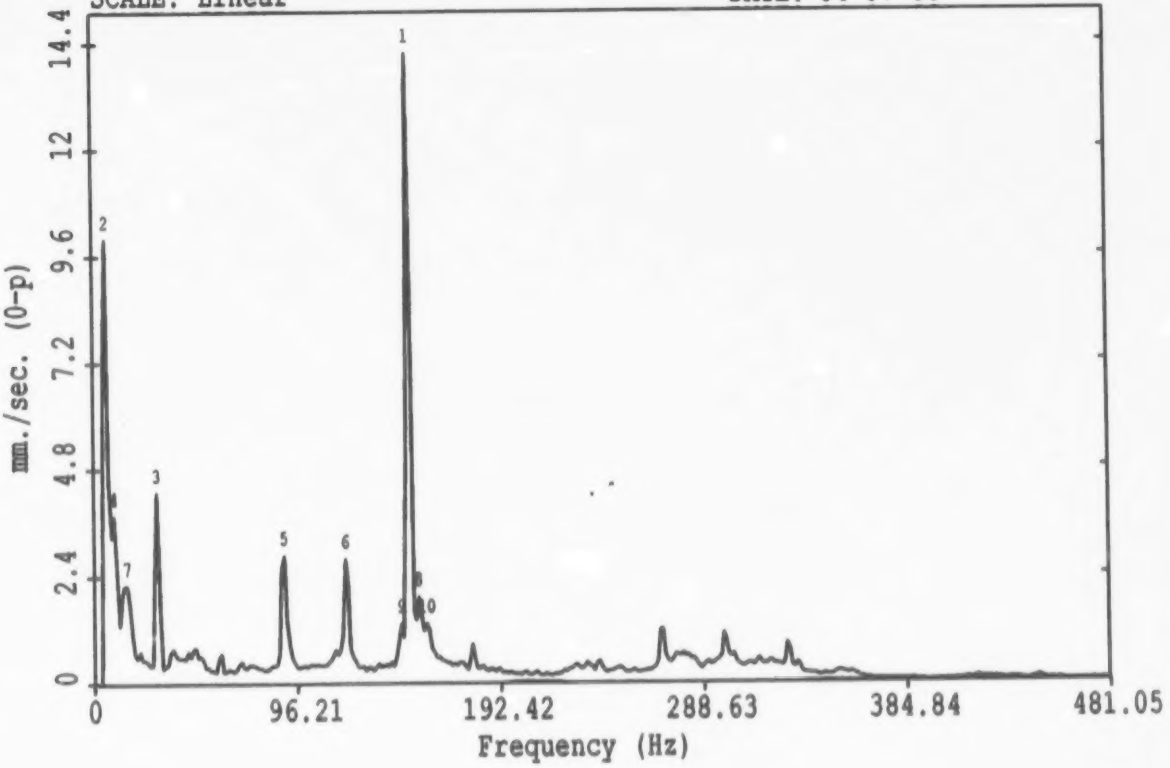


FIGURE 40

PNGS Unit 2 - ECIS Test #1 Moderator Pumpset Vibration

SIGNAL : Pumpset #3 - Motor Casing Velocity N-S
PROCESS CONDITION : Dump Test Loc 1

PEAK NO.	FREQUENCY	AMPLITUDE
1	7.2	9.04
2	90.2	2.76
3	149.1	2.04
4	79.4	1.90
5	68.6	1.86
6	74.6	1.84
7	30.1	1.48
8	64.9	1.33
9	15.6	1.06
10	60.1	1.02

SCALE: Linear DATE: 04-07-88

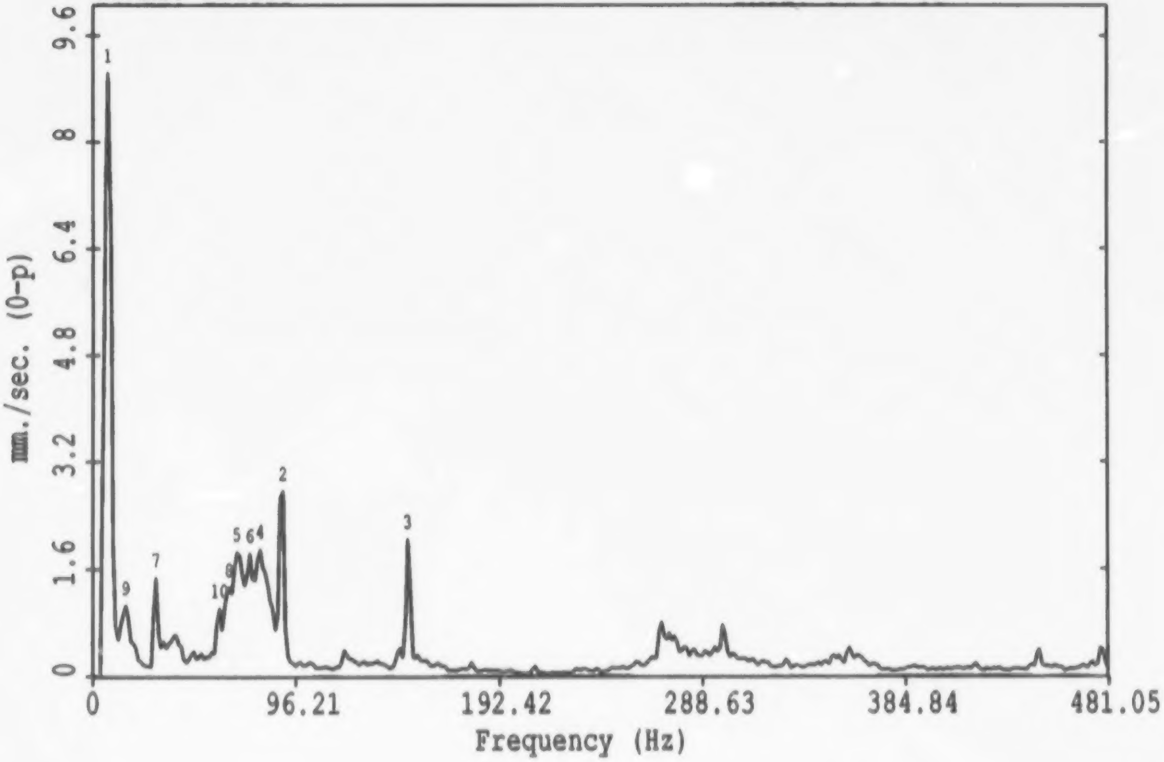


FIGURE 41

PNGS Unit 2 - ECIS Test #1 Moderator Pumpset Vibration

SIGNAL : Pumpset #4 - Motor Casing Velocity E-W
PROCESS CONDITION : Dump Test Loc 1

PEAK NO.	FREQUENCY	AMPLITUDE
1	7.2	8.75
2	30.1	2.58
3	60.1	2.56
4	15.6	1.98
5	34.9	0.98
6	149.1	0.96
7	62.5	0.87
8	64.9	0.74
9	21.6	0.61
10	46.9	0.33

SCALE: Linear

DATE: 04-07-88

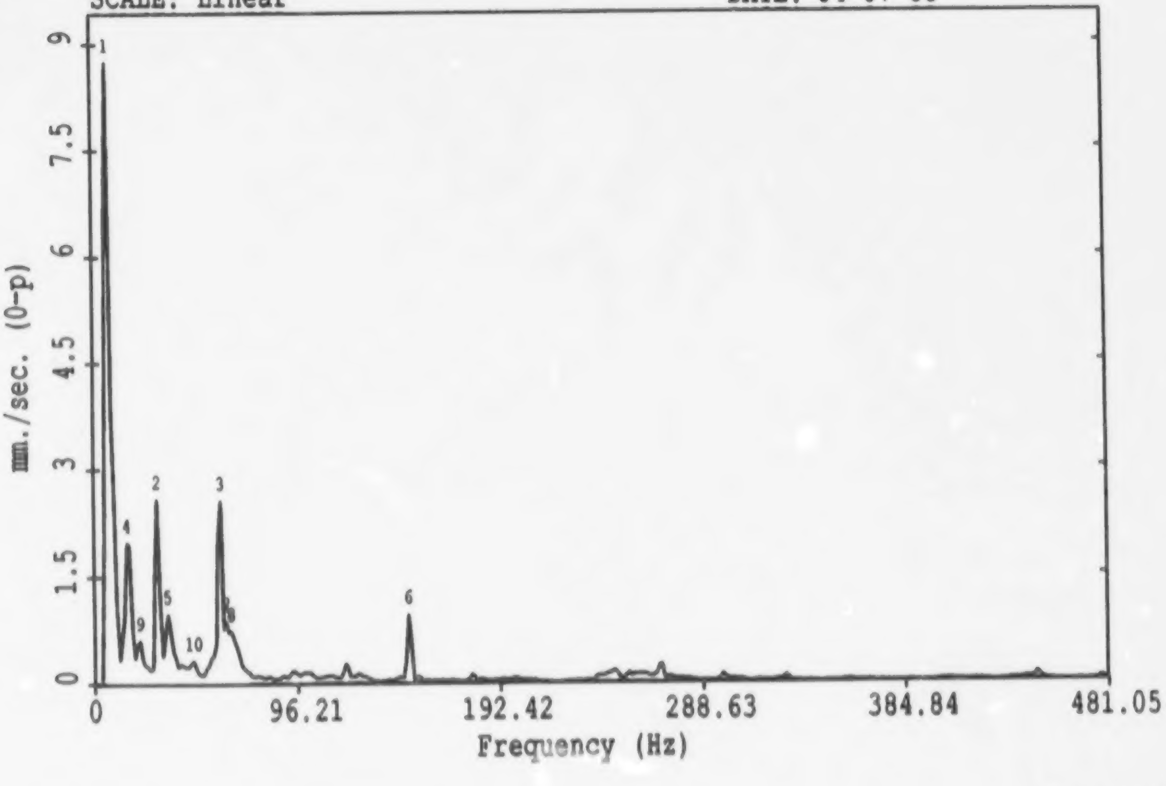


FIGURE 42

PNGS Unit 2 - ECIS Test #1 Moderator Pumpset Vibration

SIGNAL : Pumpset #5 - Motor Casing Vel E-W
PROCESS CONDITION : Dump Test Loc 1

PEAK NO.	FREQUENCY	AMPLITUDE
1	7.2	8.60
2	149.1	4.66
3	60.1	4.21
4	19.2	2.74
5	89.0	2.52
6	268.2	2.36
7	30.1	2.21
8	62.5	2.06
9	33.7	1.64
10	328.3	1.13

SCALE: Linear DATE: 04-07-88

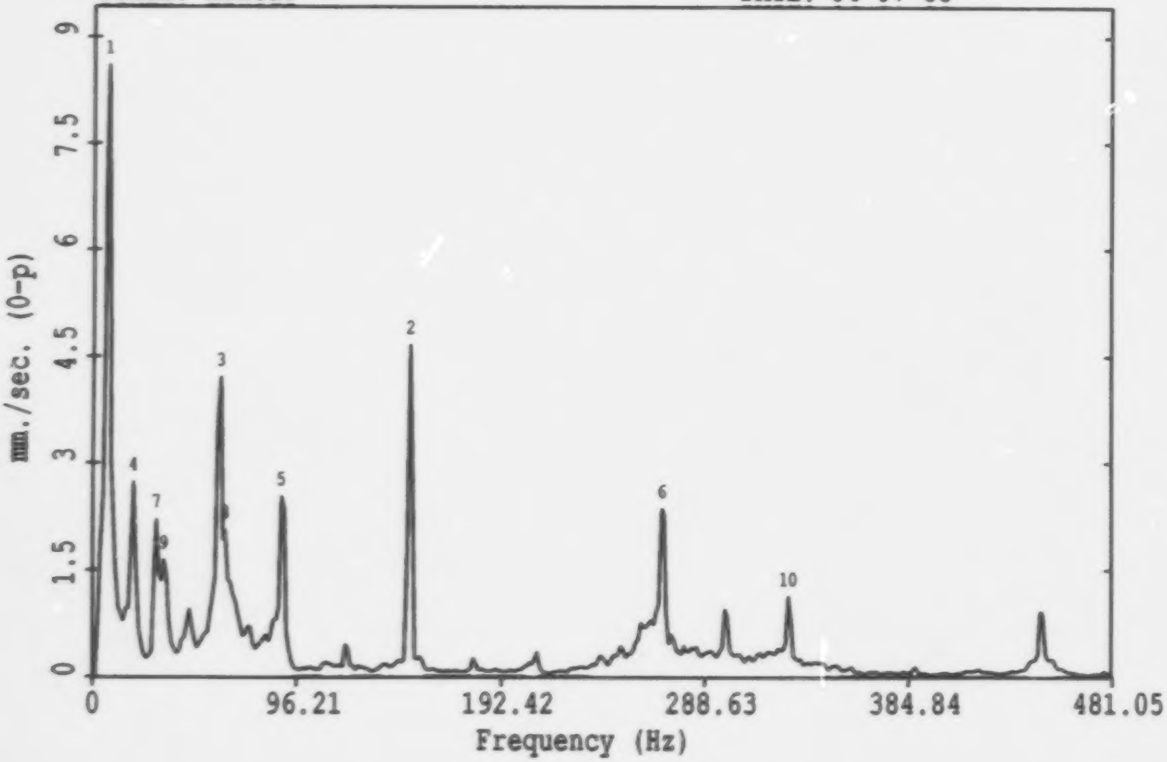


FIGURE 43

PNGS Unit 2 - ECIS Test #1 Moderator Pumpset Vibration

SIGNAL : Pumpset #5 - Motor Casing Vel N-S
PROCESS CONDITION : Dump Test Loc 1

PEAK NO.	FREQUENCY	AMPLITUDE
1	149.1	6.21
2	9.6	6.16
3	4.8	6.06
4	44.5	2.00
5	30.1	1.77
6	19.2	1.70
7	89.0	1.23
8	60.1	1.15
9	15.6	1.05
10	298.3	1.03

SCALE: Linear

DATE: 04-07-88

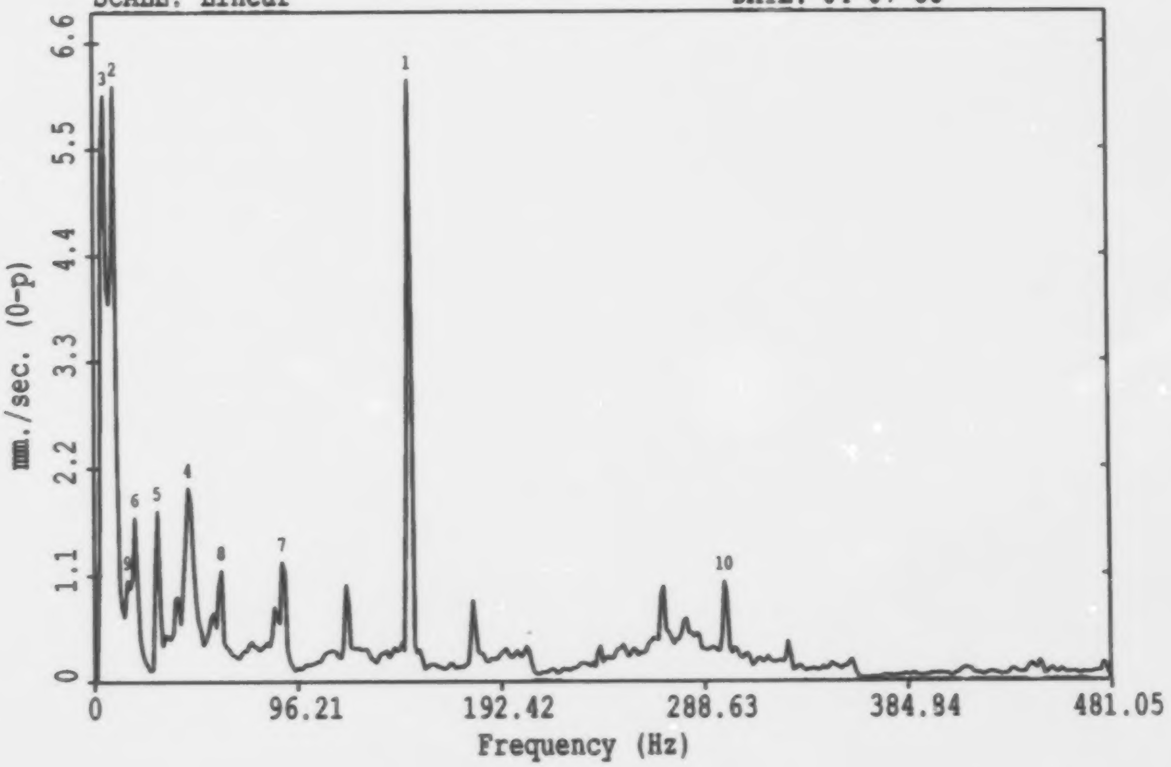


FIGURE 44

PNGS Unit 2 - ECIS Test #1 Moderator Pumpset Vibration

SIGNAL : Pumpset #1 - Pump Shaft Displacement E-W
PROCESS CONDITION : Dump Test Loc 1

PEAK NO.	FREQUENCY	AMPLITUDE
1	149.1	95.23
2	30.1	62.53
3	60.1	26.88
4	89.0	21.48
5	179.2	11.52
6	119.1	11.34
7	80.6	8.15
8	209.3	8.09
9	83.0	7.99
10	6.0	6.07

SCALE: Linear

DATE: 04-07-88

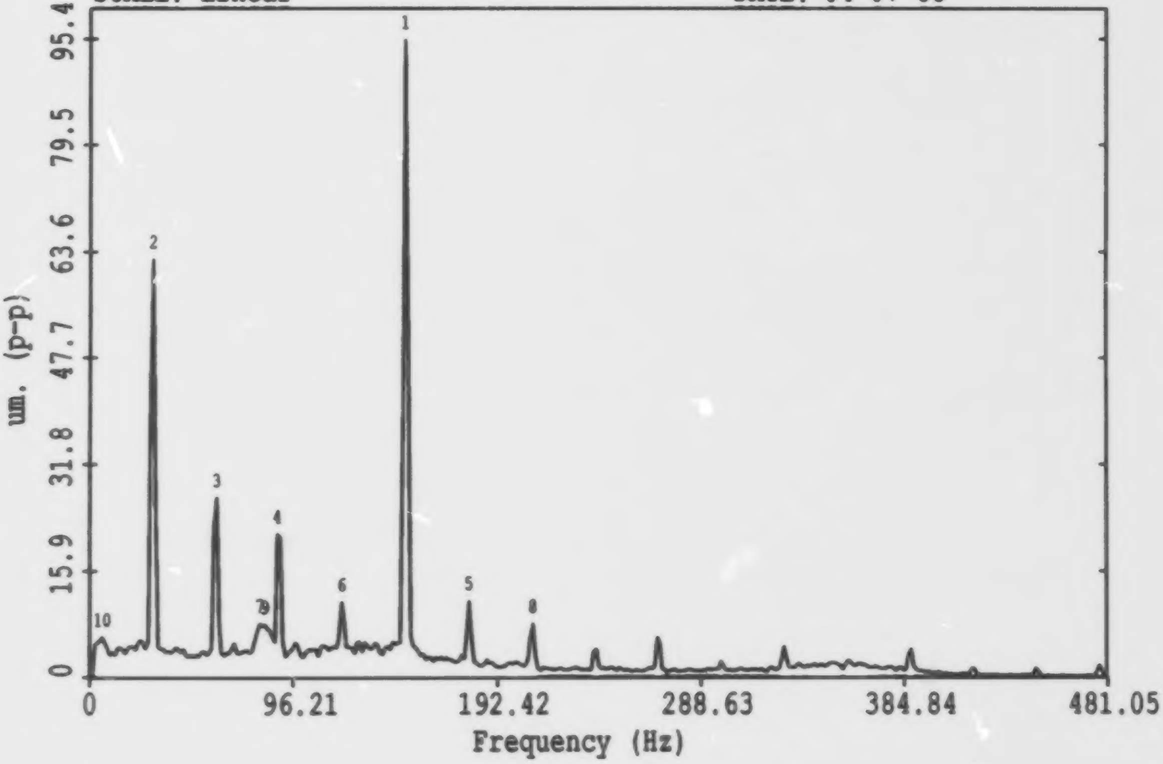


FIGURE 45

PNGS Unit 2 - ECIS Test #1 Moderator Pumpset Vibration

SIGNAL : Pumpset #1 - Pump Shaft Displacement N-S
PROCESS CONDITION : Dump Test Loc 1

PEAK NO.	FREQUENCY	AMPLITUDE
1	30.1	117.30
2	149.1	102.10
3	89.0	24.47
4	60.1	21.96
5	6.0	10.01
6	119.1	8.50
7	209.3	8.08
8	73.4	6.91
9	63.7	6.71
10	75.8	6.52

SCALE: Linear

DATE: 04-07-88

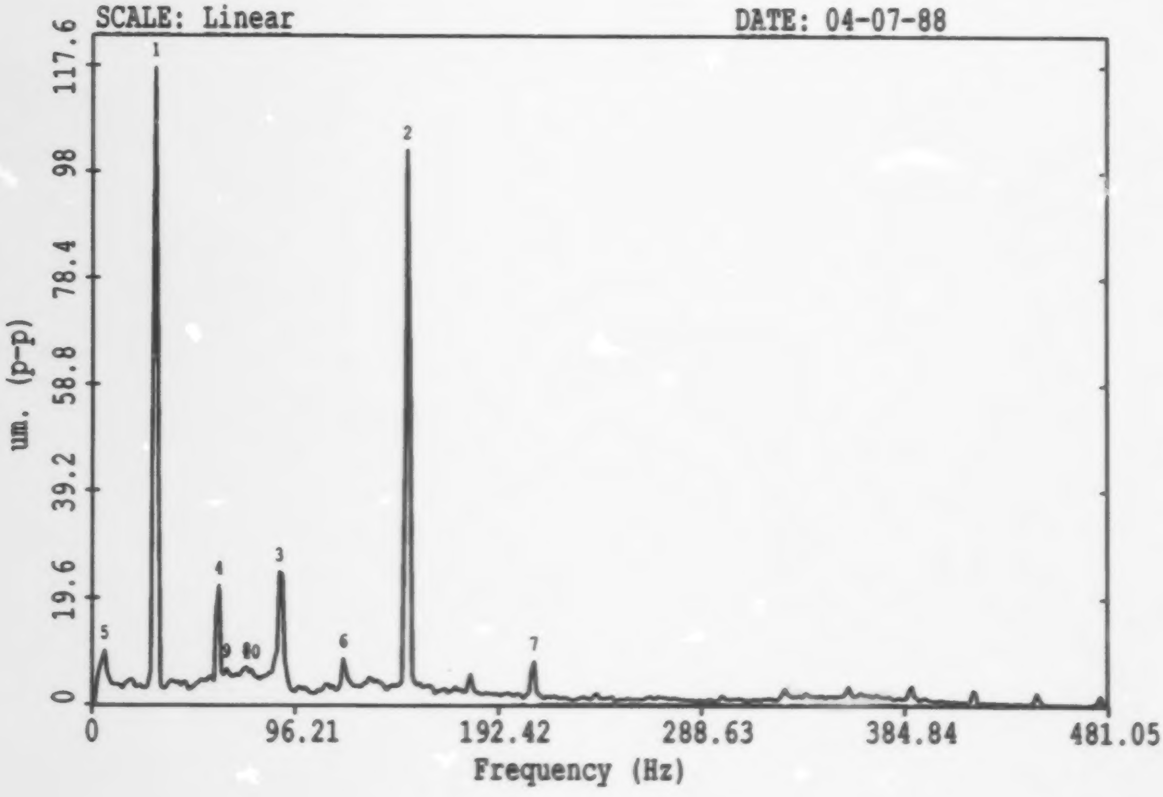


FIGURE 46

PNGS Unit 2 - ECIS Test #1 Moderator Pumpset Vibration

SIGNAL : Pumpset #2 - Pump Shaft Displacement E-W
PROCESS CONDITION : Dump Test Loc 1

PEAK NO.	FREQUENCY	AMPLITUDE
1	30.1	133.70
2	149.1	61.02
3	60.1	29.48
4	179.2	15.55
5	119.1	13.94
6	298.3	13.14
7	89.0	8.71
8	268.2	7.14
9	157.5	5.95
10	328.3	5.55

SCALE: Linear DATE: 04-07-88

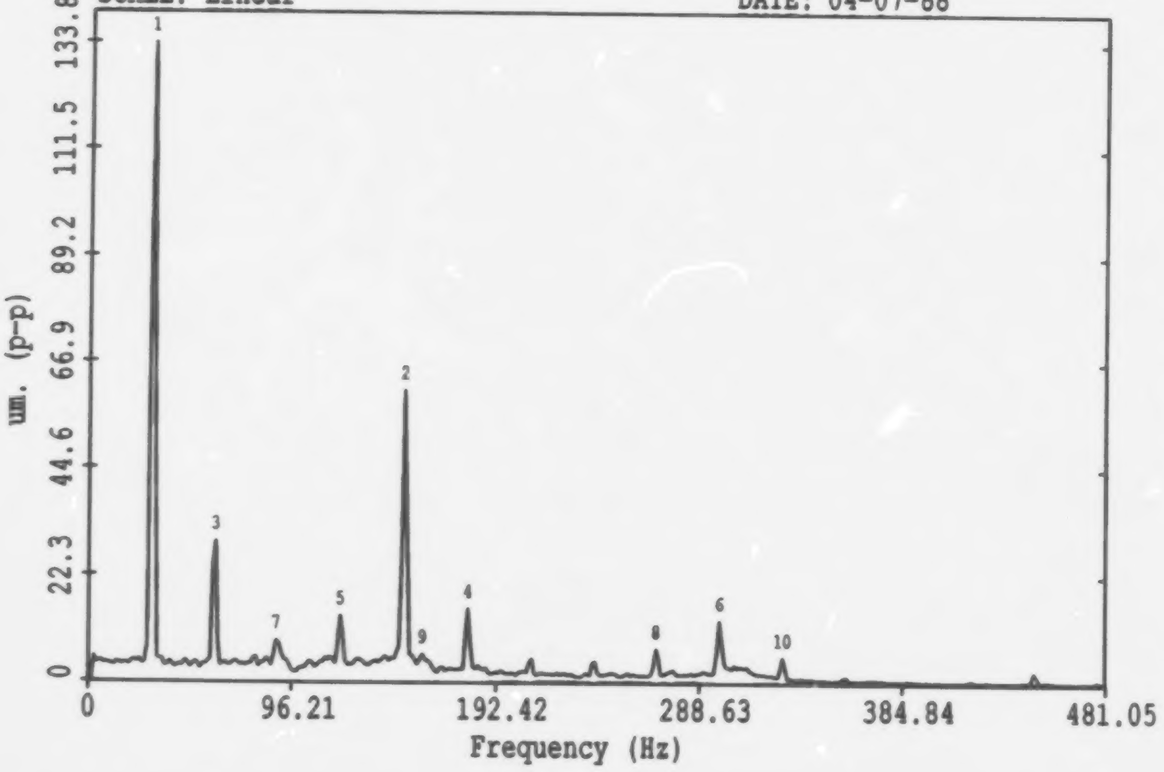


FIGURE 47

PNGS Unit 2 - ECIS Test #1 Moderator Pumpset Vibration

SIGNAL : Pumpset #2 - Pump Shaft Displacement N-S
PROCESS CONDITION : Dump Test Loc 1

PEAK NO.	FREQUENCY	AMPLITUDE
1	30.1	157.70
2	60.1	41.37
3	149.1	21.41
4	2.4	8.11
5	4.8	6.44
6	8.4	6.16
7	119.1	6.13
8	21.6	6.07
9	13.2	6.03
10	24.1	5.95

SCALE: Linear

DATE: 04-07-88

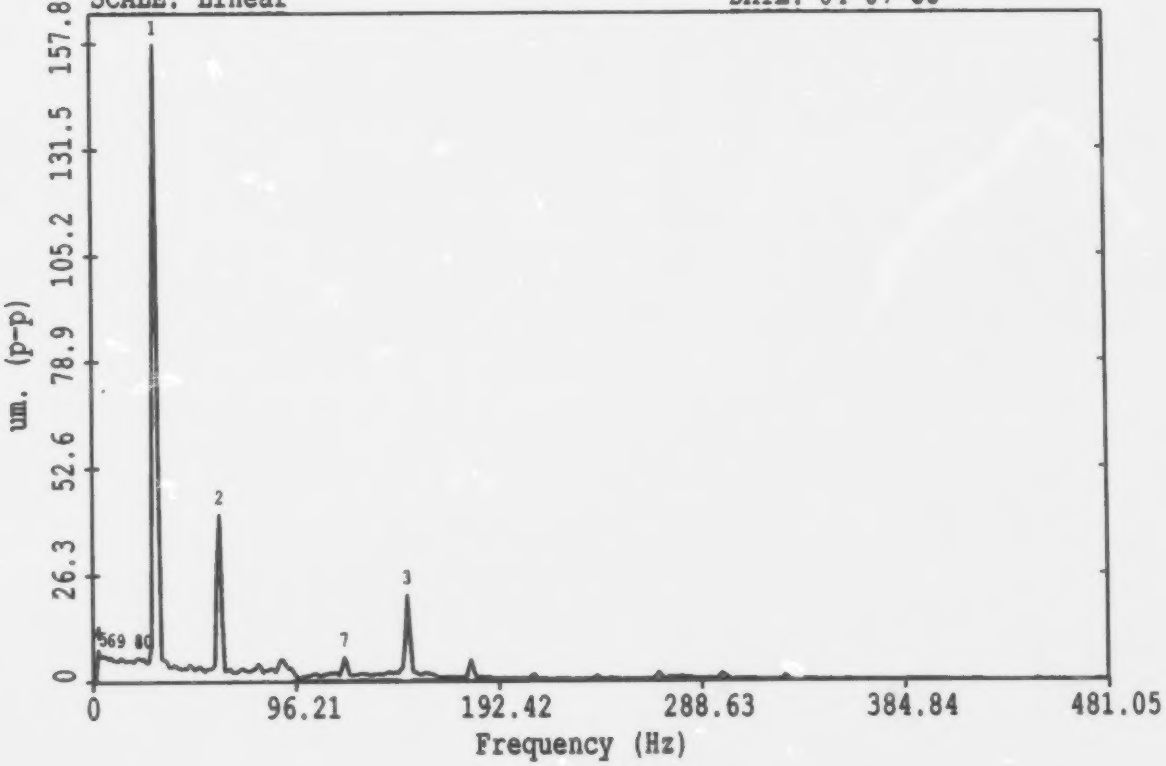


FIGURE 48

PNGS Unit 2 - ECIS Test #1 Moderator Pumpset Vibration

SIGNAL : Pumpset #3 - Pump Shaft Displacement E-W
PROCESS CONDITION : Dump Test Loc 1

PEAK NO.	FREQUENCY	AMPLITUDE
1	30.1	192.20
2	149.1	96.25
3	60.1	16.85
4	7.2	16.81
5	90.2	16.36
6	78.2	9.35
7	74.6	9.23
8	120.3	9.00
9	144.3	8.57
10	93.8	7.74

SCALE: Linear

DATE: 04-07-88

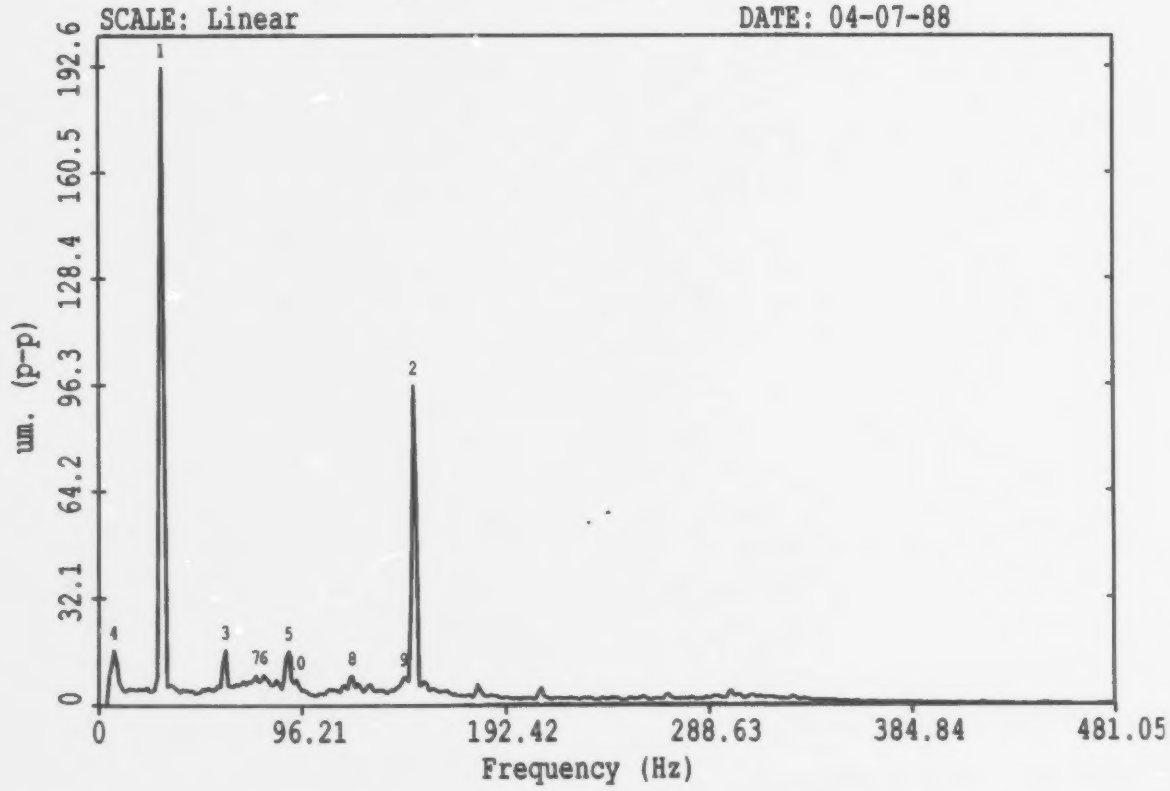


FIGURE 49

PNGS Unit 2 - ECIS Test #1 Moderator Pumpset Vibration

SIGNAL : Pumpset #4 - Pump Shaft Displacement E-W
PROCESS CONDITION : Dump Test Loc 1

PEAK NO.	FREQUENCY	AMPLITUDE
1	149.1	11.19
2	60.1	9.35
3	9.6	9.01
4	7.2	6.46
5	119.1	4.65
6	16.8	4.29
7	62.5	3.94
8	64.9	3.81
9	30.1	2.89
10	89.0	2.78

SCALE: Linear

DATE: 04-07-88

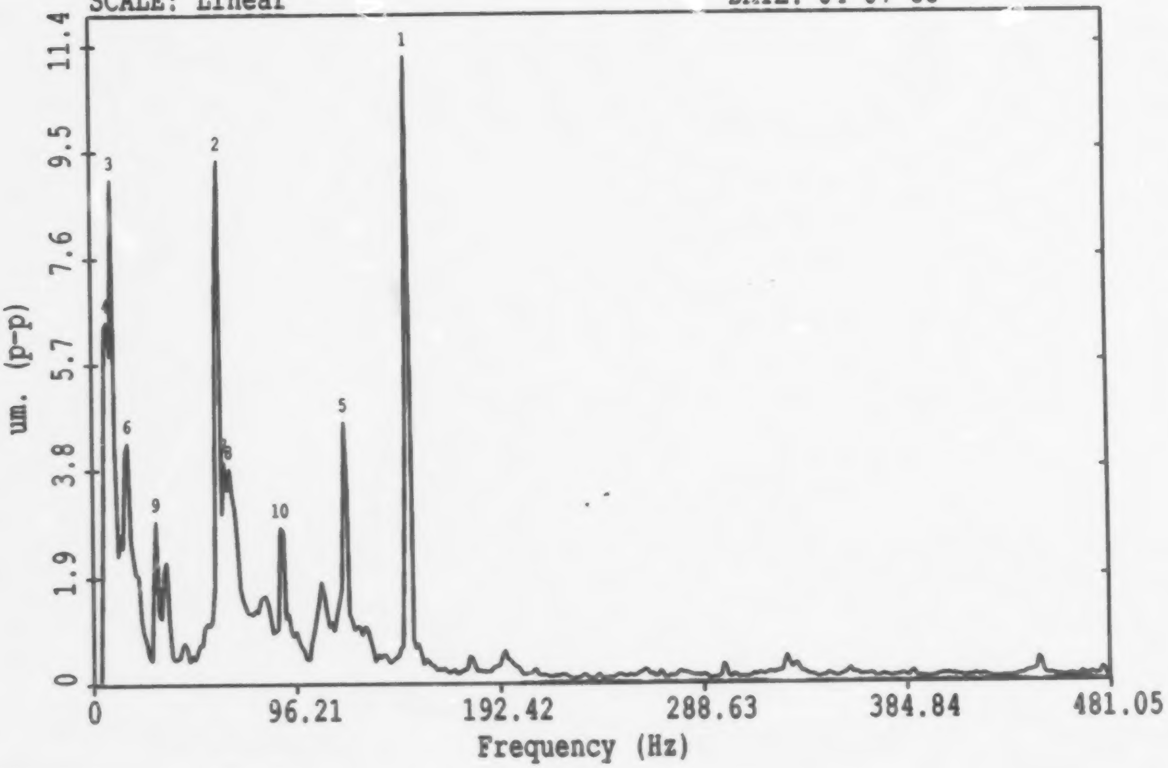


FIGURE 50

PNGS Unit 2 - ECIS Test #1 Moderator Pumpset Vibration

SIGNAL : Pumpset #5 - Pump Shaft Displacement E-W
PROCESS CONDITION : Dump Test Loc 1

PEAK NO.	FREQUENCY	AMPLITUDE
1	149.1	130.00
2	30.1	113.70
3	60.1	18.72
4	89.0	15.66
5	119.1	11.04
6	7.2	10.44
7	153.9	9.90
8	85.4	9.07
9	74.6	8.16
10	55.3	7.91

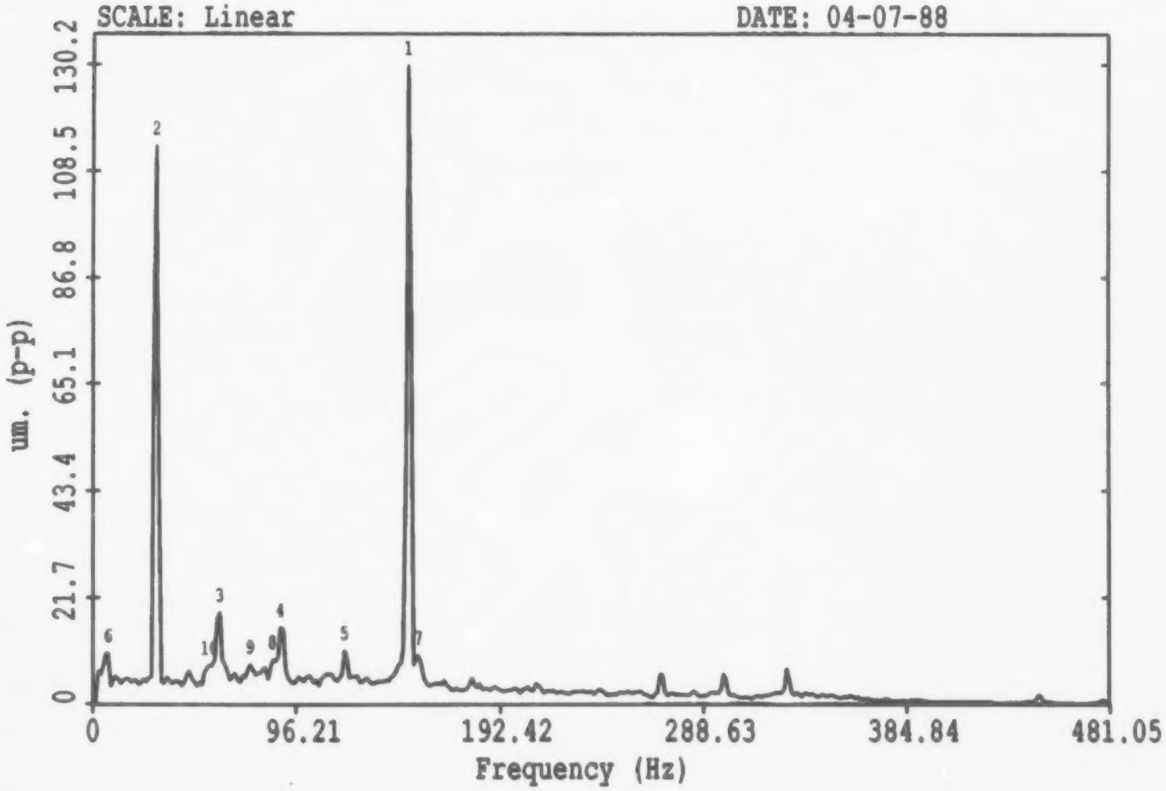


FIGURE 51

PNGS Unit 2 - ECIS Test #1 Moderator Pumpset Vibration

SIGNAL : Pumpset #5 - Pump Shaft Displacement N-S
PROCESS CONDITION : Dump Test Loc 1

PEAK NO.	FREQUENCY	AMPLITUDE
1	149.1	126.00
2	30.1	86.70
3	60.1	27.18
4	89.0	23.49
5	119.1	10.93
6	153.9	8.73
7	7.2	8.18
8	268.2	7.59
9	85.4	7.52
10	144.3	7.39

SCALE: Linear

DATE: 04-07-88

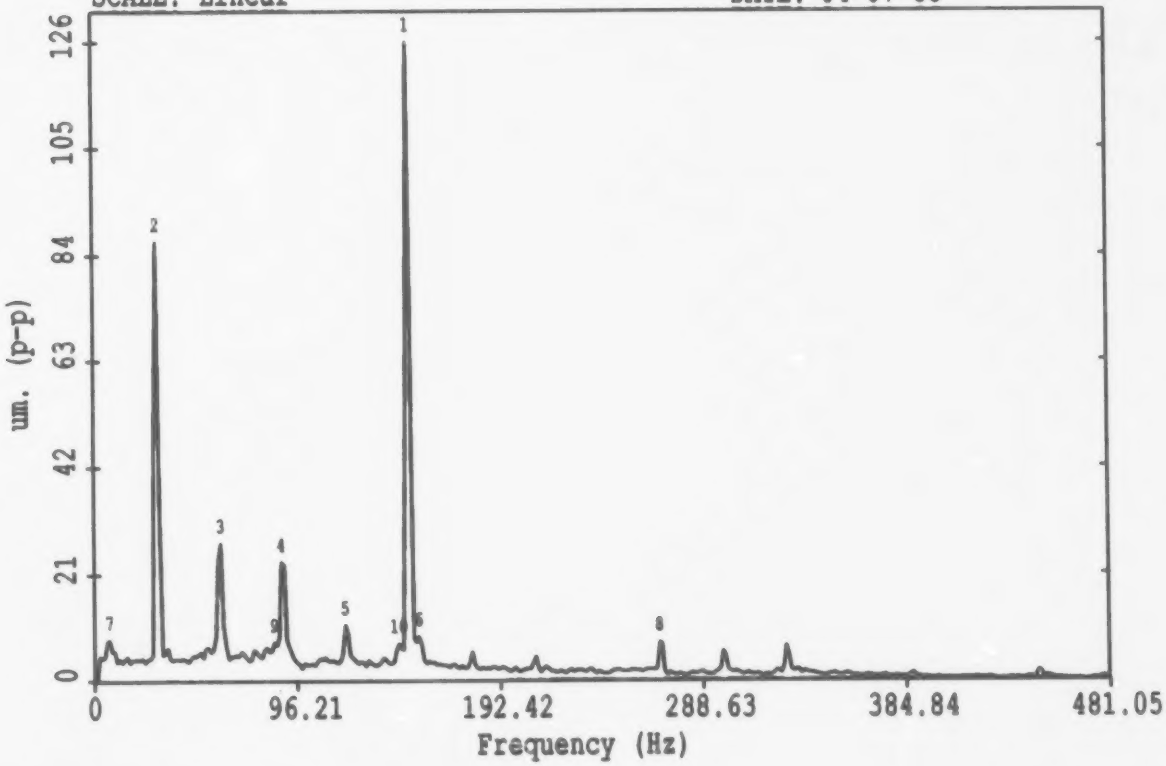


FIGURE 52

PNGS Unit 2 - ECIS Test #1 Moderator Pumpset Vibration

SIGNAL : Expansion Joint #3 Vertical Velocity
PROCESS CONDITION : Dump Test Loc 1

PEAK NO.	FREQUENCY	AMPLITUDE
1	4.8	6.11
2	16.8	4.51
3	8.4	4.03
4	149.1	3.76
5	60.1	2.61
6	119.1	1.88
7	30.1	1.70
8	45.7	1.60
9	42.1	1.43
10	36.1	0.91

SCALE: Linear

DATE: 04-07-88

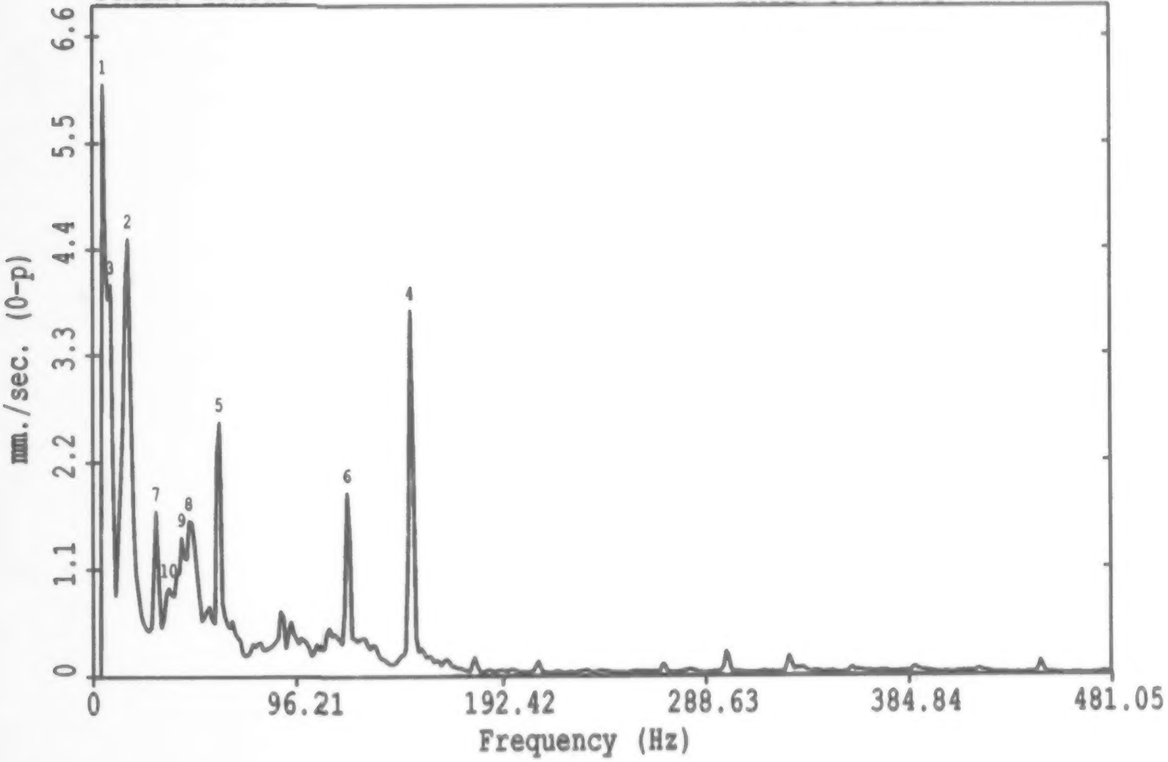


FIGURE 53

PNGS Unit 2 - ECIS Test #1 Moderator Pumpset Vibration

SIGNAL : Expansion Joint #3 Horizontal Velocity
PROCESS CONDITION : Dump Test Loc 1

PEAK NO.	FREQUENCY	AMPLITUDE
1	4.8	6.02
2	149.1	5.47
3	60.1	4.69
4	16.8	4.24
5	8.4	3.90
6	66.1	1.88
7	68.6	1.74
8	30.1	1.67
9	119.1	1.66
10	89.0	1.52

SCALE: Linear DATE: 04-07-88

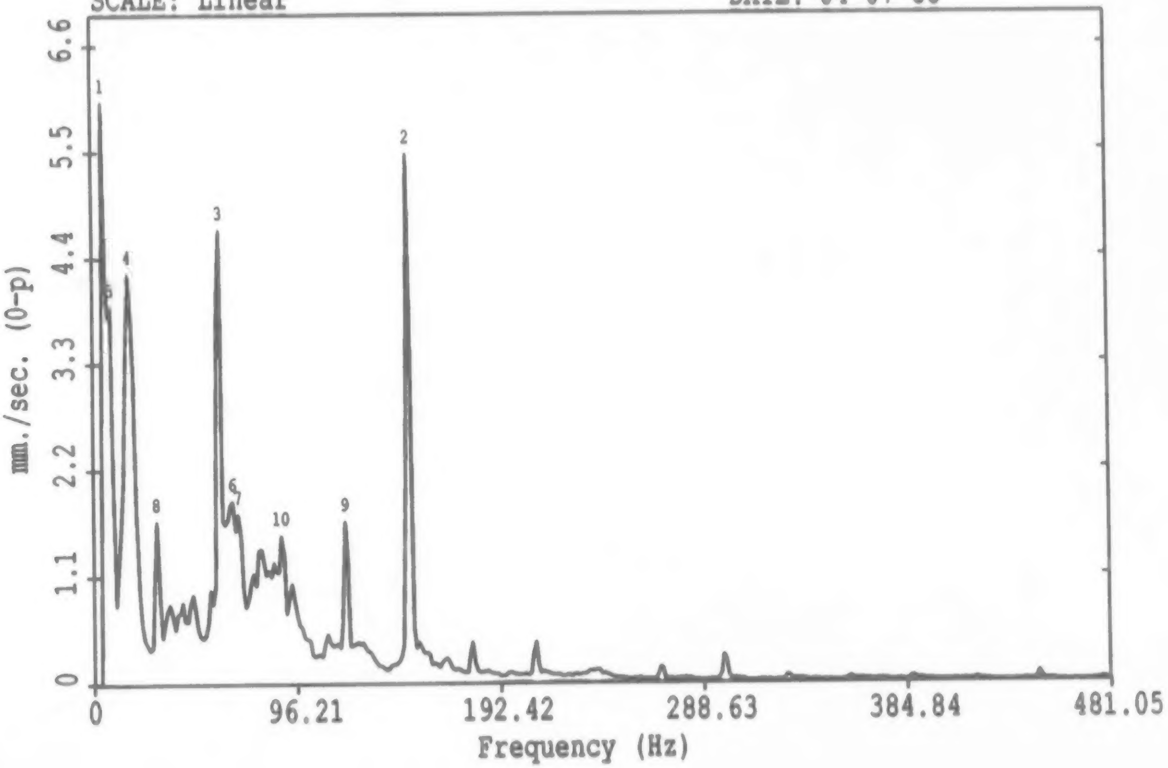


FIGURE 54

PNGS Unit 2 - ECIS Test #1 Moderator Pumpset Vibration

SIGNAL : Expansion Joint #3 Axial Velocity
PROCESS CONDITION : Dump Test Loc 1

PEAK NO.	FREQUENCY	AMPLITUDE
1	30.1	7.89
2	16.8	5.41
3	4.8	5.36
4	19.2	4.73
5	8.4	4.65
6	149.1	4.24
7	119.1	3.40
8	48.1	1.78
9	36.1	1.24
10	179.2	0.98

SCALE: Linear

DATE: 04-07-88

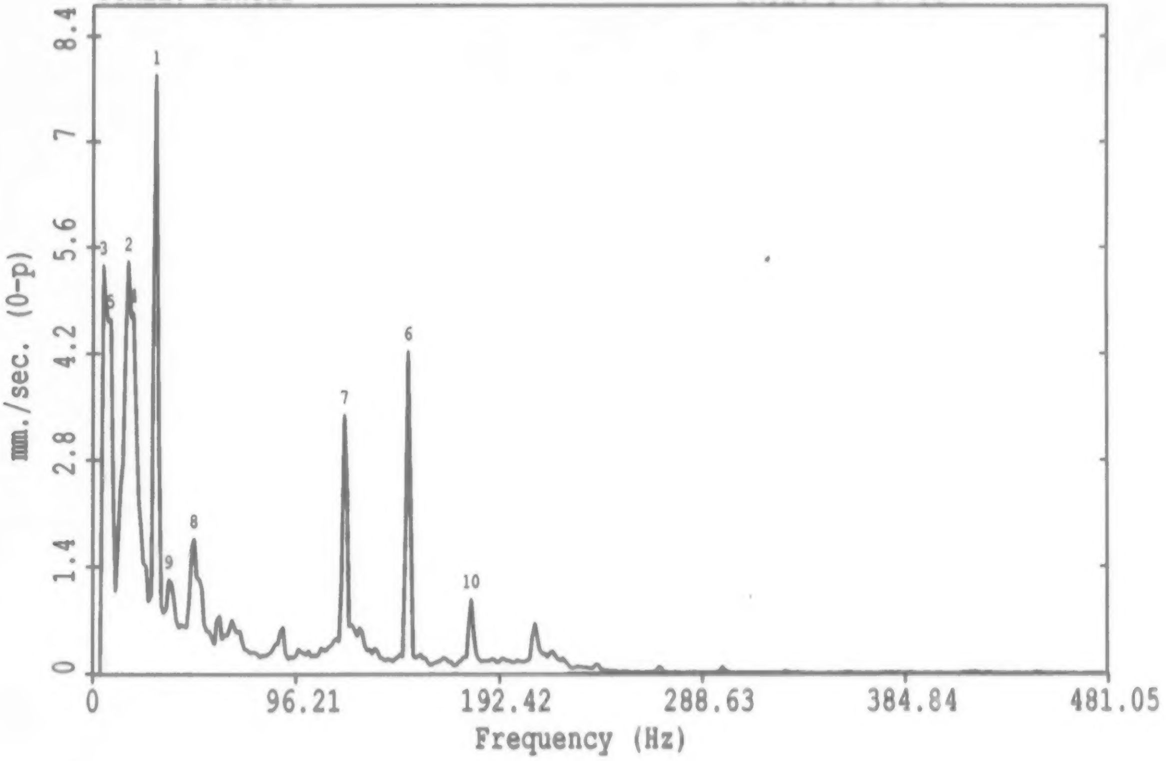


FIGURE 55

PNGS Unit 2 - ECIS Test #1 Moderator Pumpset Vibration

SIGNAL : Expansion Joint #4 Vertical Velocity
PROCESS CONDITION : Dump Test Loc 1

PEAK NO.	FREQUENCY	AMPLITUDE
1	4.8	6.50
2	16.8	6.25
3	9.6	3.08
4	21.6	1.73
5	33.7	1.37
6	149.1	0.85
7	119.1	0.41
8	45.7	0.24
9	89.0	0.20
10	60.1	0.14

SCALE: Linear DATE: 04-07-88

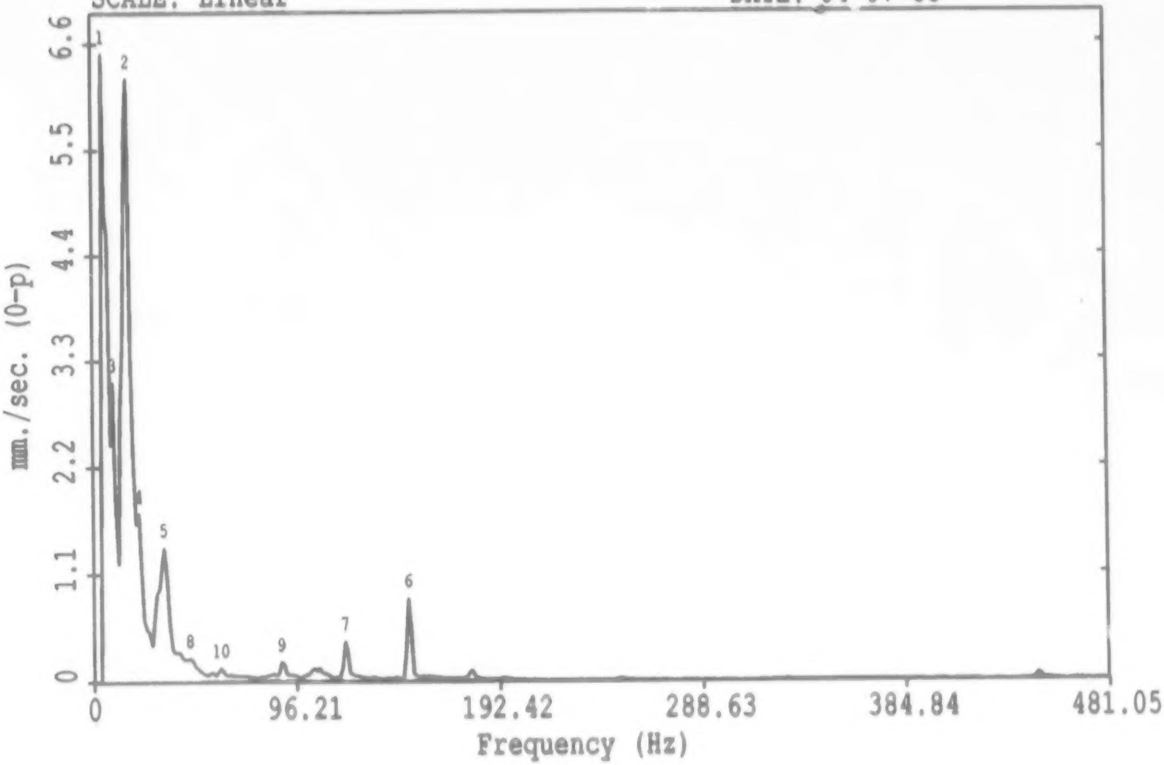


FIGURE 56

PNGS Unit 2 - ECIS Test #1 Moderator Pumpset Vibration

SIGNAL : Expansion Joint #4 Horizontal Velocity
PROCESS CONDITION : Dump Test Loc 1

PEAK NO.	FREQUENCY	AMPLITUDE
1	15.6	7.52
2	4.8	6.87
3	7.2	5.46
4	9.6	3.33
5	30.1	2.64
6	56.5	1.86
7	51.7	1.86
8	43.3	1.63
9	149.1	1.63
10	40.9	1.59

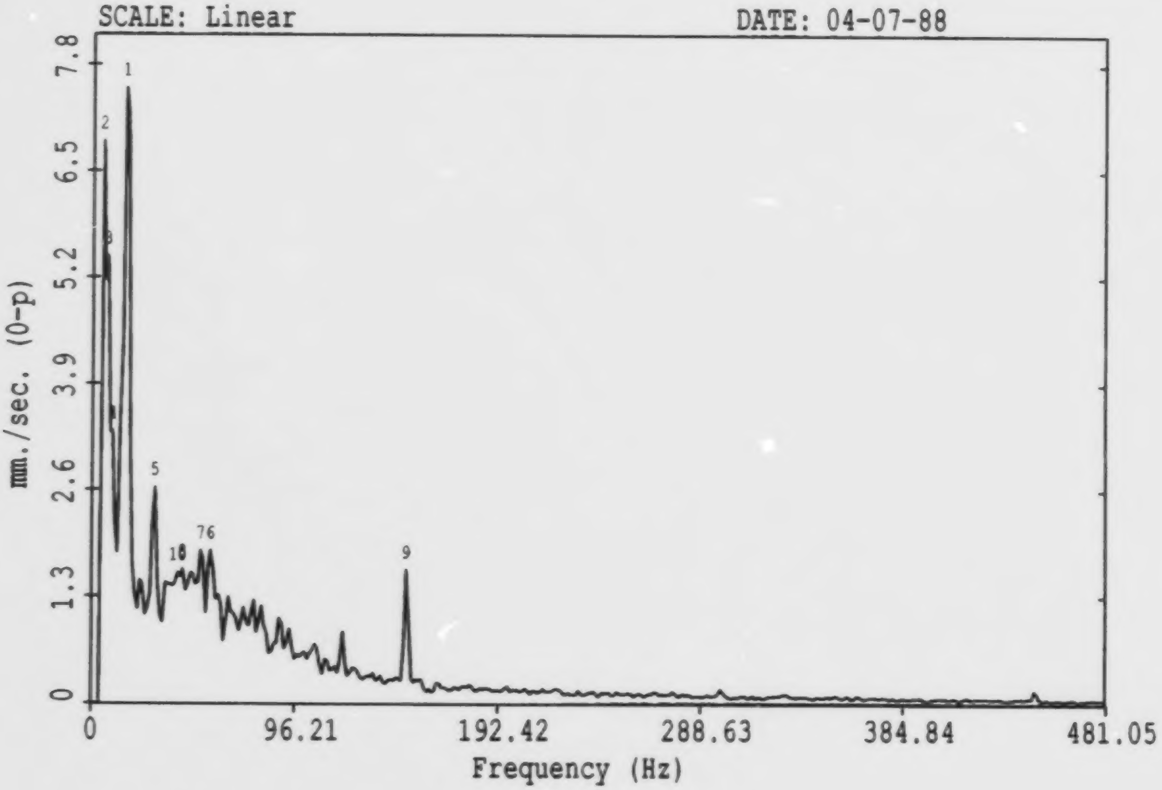


FIGURE 57

PNGS Unit 2 - ECIS Test #1 Moderator Pumpset Vibration

SIGNAL : Expansion Joint #4 Axial Velocity
PROCESS CONDITION : Dump Test Loc 1

PEAK NO.	FREQUENCY	AMPLITUDE
2	19.2	3.26
3	15.6	2.89
4	4.8	2.56
5	9.6	2.33
6	30.1	1.67
7	149.1	1.61
8	119.1	1.23
9	64.9	1.11
10	34.9	0.81

SCALE: Linear DATE: 04-07-88

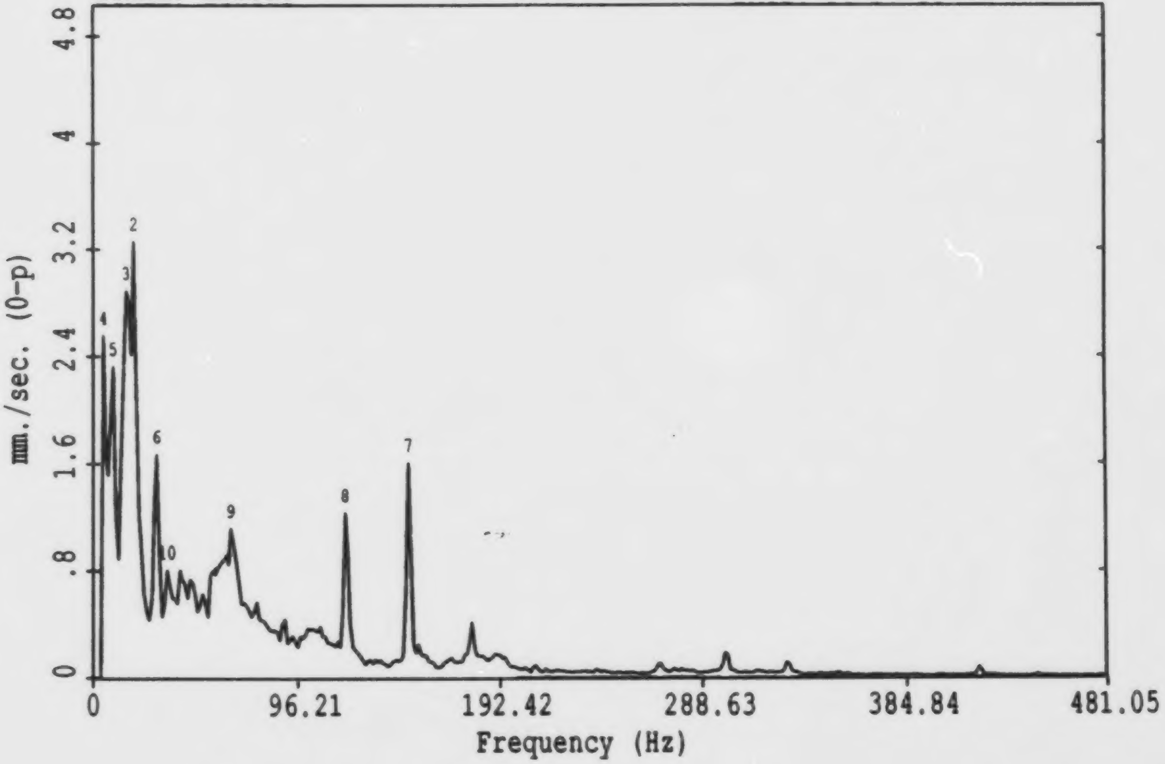


FIGURE 58

PNGS Unit 2 - ECIS Test #1 Moderator Pumpset Vibration

SIGNAL : Pumpset #1 - Motor Casing Vel N-S
PROCESS CONDITION : Dump Test Loc 2

PEAK NO.	FREQUENCY	AMPLITUDE
1	4.8	12.17
2	149.1	4.62
3	30.1	3.16
4	60.1	1.69
5	64.9	1.54
6	74.6	1.43
7	78.2	1.38
8	15.6	1.29
9	21.6	1.13
10	39.7	0.60

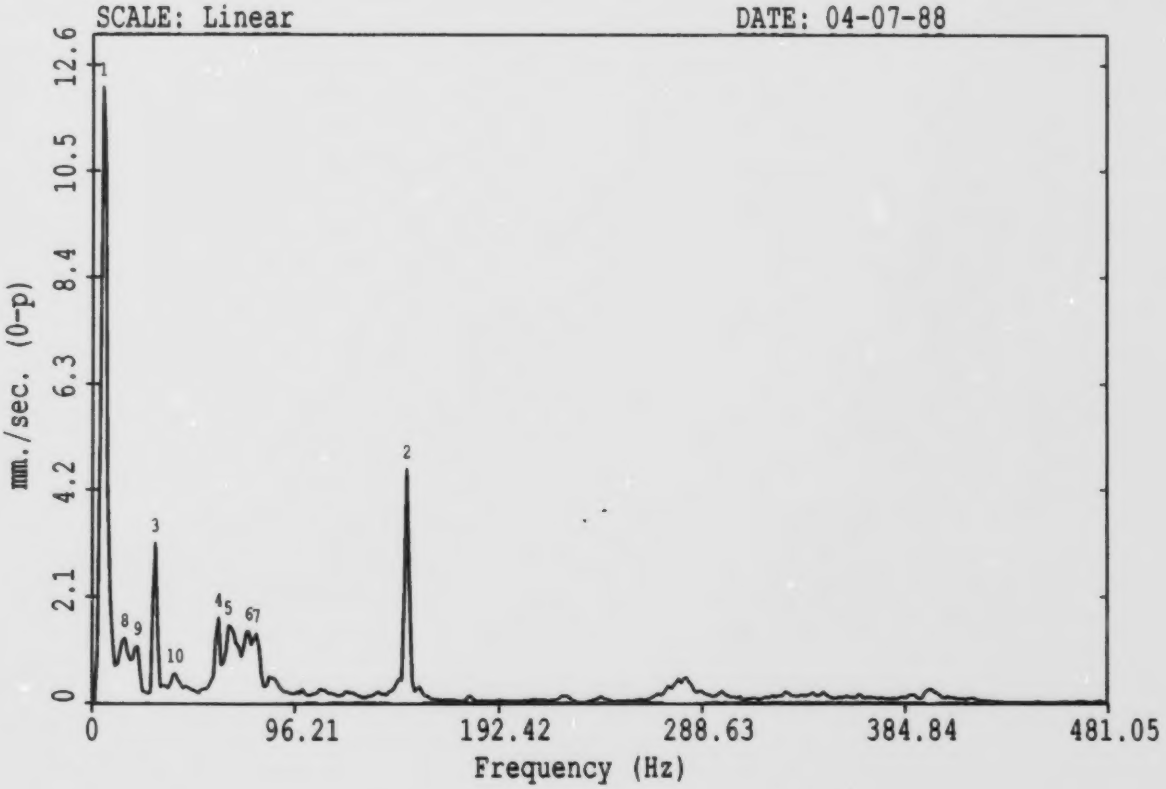


FIGURE 59

PNGS Unit 2 - ECIS Test #1 Moderator Pumpset Vibration

SIGNAL : Pumpset #2 - Motor Casing Vel E-W
PROCESS CONDITION : Dump Test Loc 2

PEAK NO.	FREQUENCY	AMPLITUDE
1	9.6	8.88
2	4.8	5.57
3	149.1	2.55
4	298.3	2.23
5	13.2	1.81
6	30.1	1.70
7	119.1	1.17
8	92.6	1.16
9	90.2	0.98
10	294.6	0.91

SCALE: Linear

DATE: 04-07-88

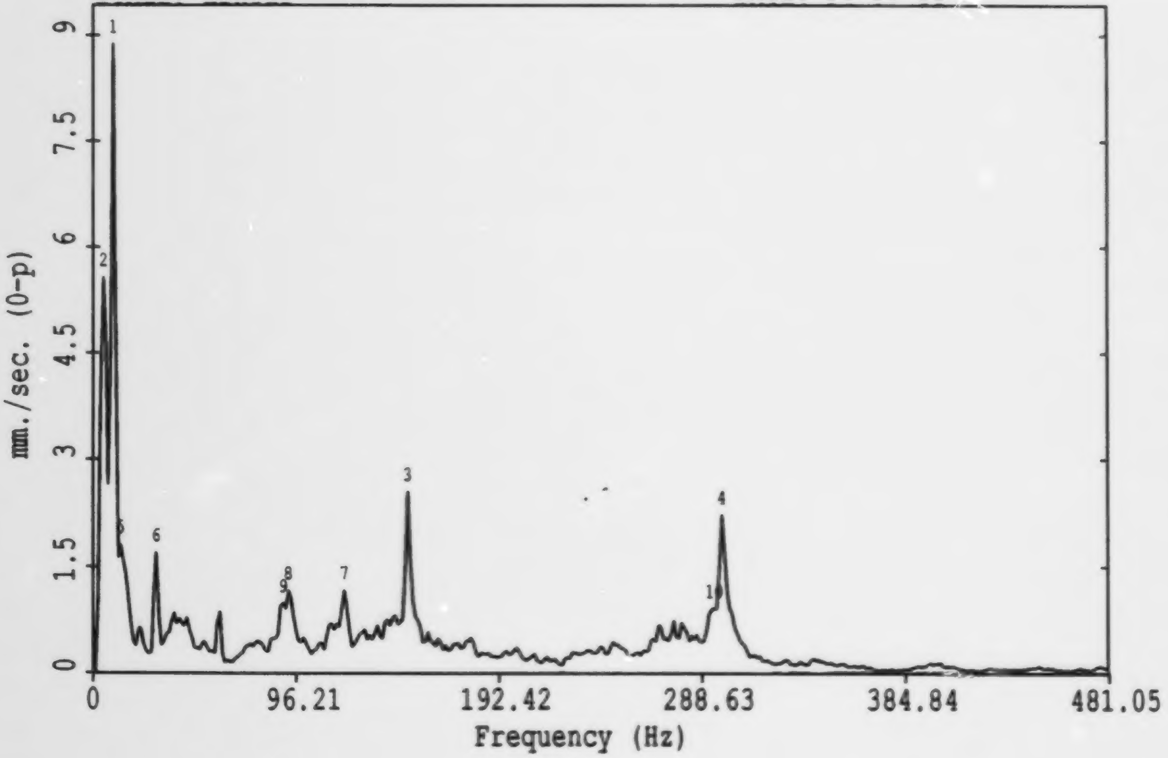


FIGURE 60

PNGS Unit 2 - ECIS Test #1 Moderator Pumpset Vibration

SIGNAL : Pumpset #2 - Motor Casing Vel N-S
PROCESS CONDITION : Dump Test Loc 2

PEAK NO.	FREQUENCY	AMPLITUDE
1	6.0	11.33
2	9.6	4.62
3	149.1	3.35
4	30.1	2.59
5	15.6	1.79
6	60.1	1.53
7	71.0	1.43
8	74.6	1.38
9	20.4	1.30
10	77.0	1.30

SCALE: Linear

DATE: 04-07-88

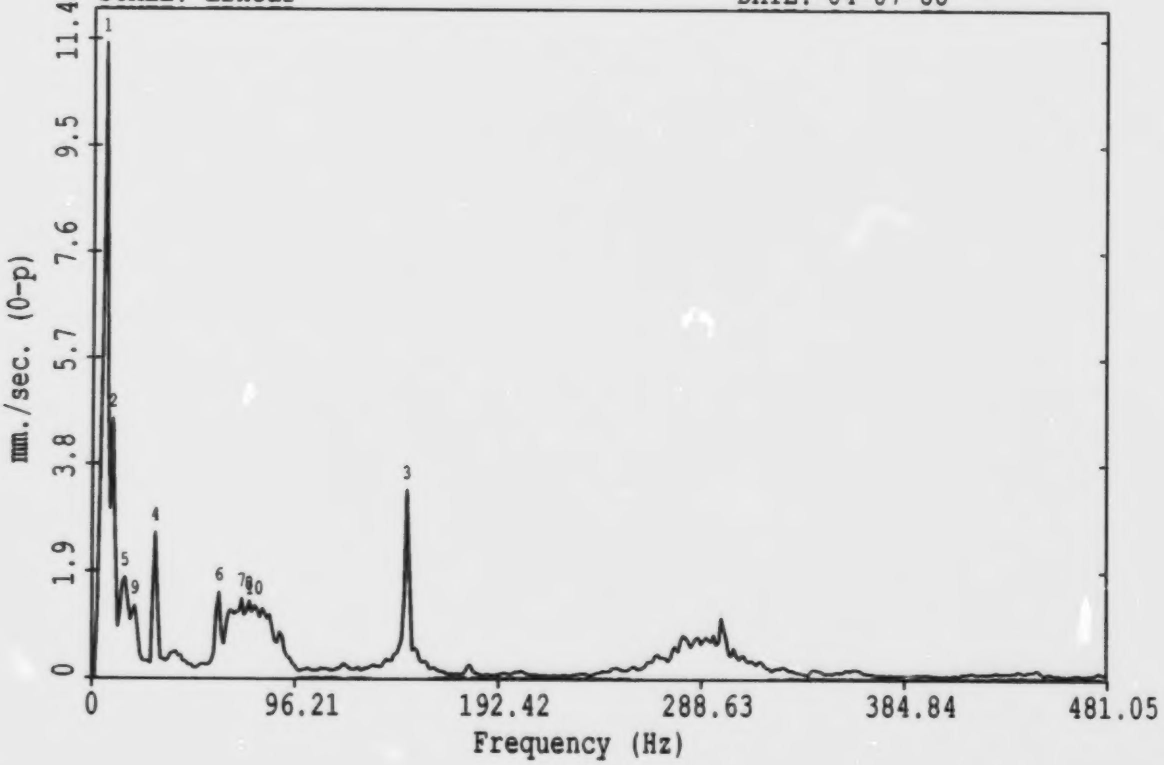


FIGURE 61

PNGS Unit 2 - ECIS Test #1 Moderator Pumpset Vibration

SIGNAL : Pumpset #3 - Motor Casing Velocity E-W
PROCESS CONDITION : Dump Test Loc #2

PEAK NO.	FREQUENCY	AMPLITUDE
1	6.0	15.83
2	9.6	5.71
3	14.4	3.40
4	30.1	2.49
5	149.1	2.38
6	298.3	1.27
7	21.6	1.02
8	39.7	0.78
9	90.2	0.76
10	60.1	0.72

SCALE: Linear DATE: 04-07-88

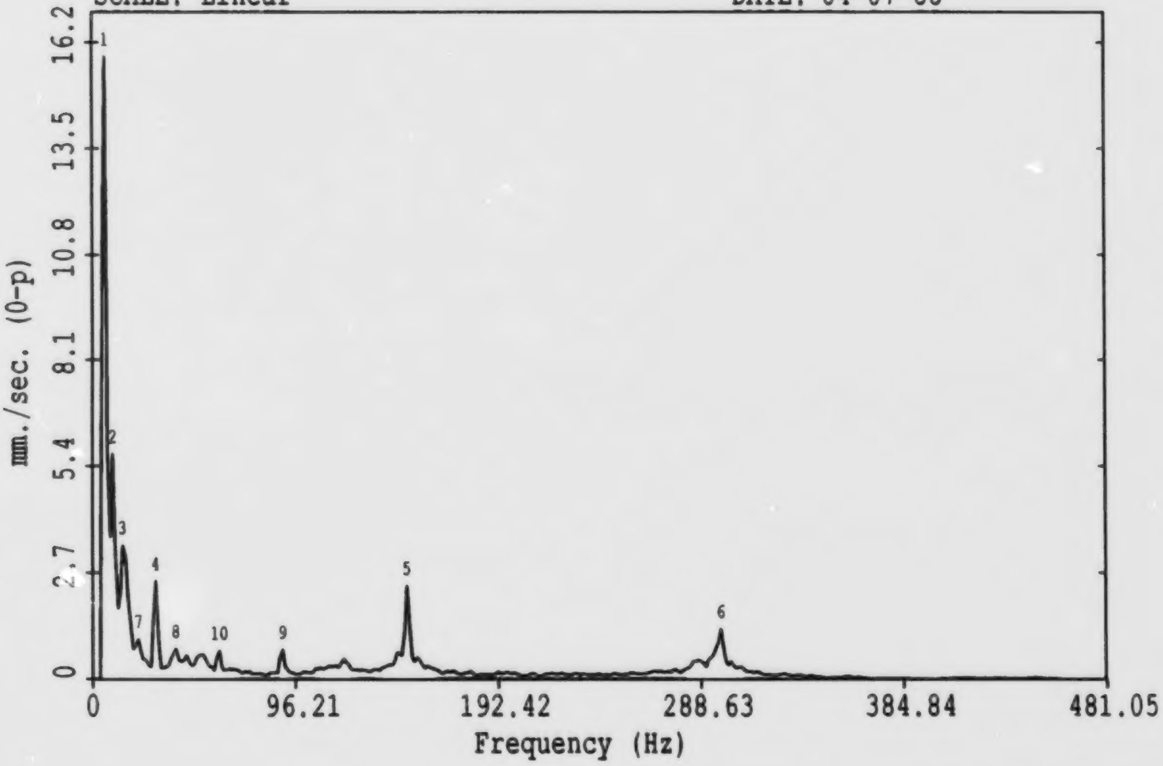


FIGURE 62

PNGS Unit 2 - ECIS Test #1 Moderator Pumpset Vibration

SIGNAL : Pumpset #3 - Motor Casing Velocity N-S
PROCESS CONDITION : Dump Test Loc #2

PEAK NO.	FREQUENCY	AMPLITUDE
1	7.2	5.12
2	149.1	2.22
3	30.1	1.65
4	14.4	1.56
5	12.0	1.20
6	69.8	0.92
7	60.1	0.80
8	78.2	0.66
9	74.6	0.59
10	145.5	0.54

SCALE: Linear

DATE: 04-07-88

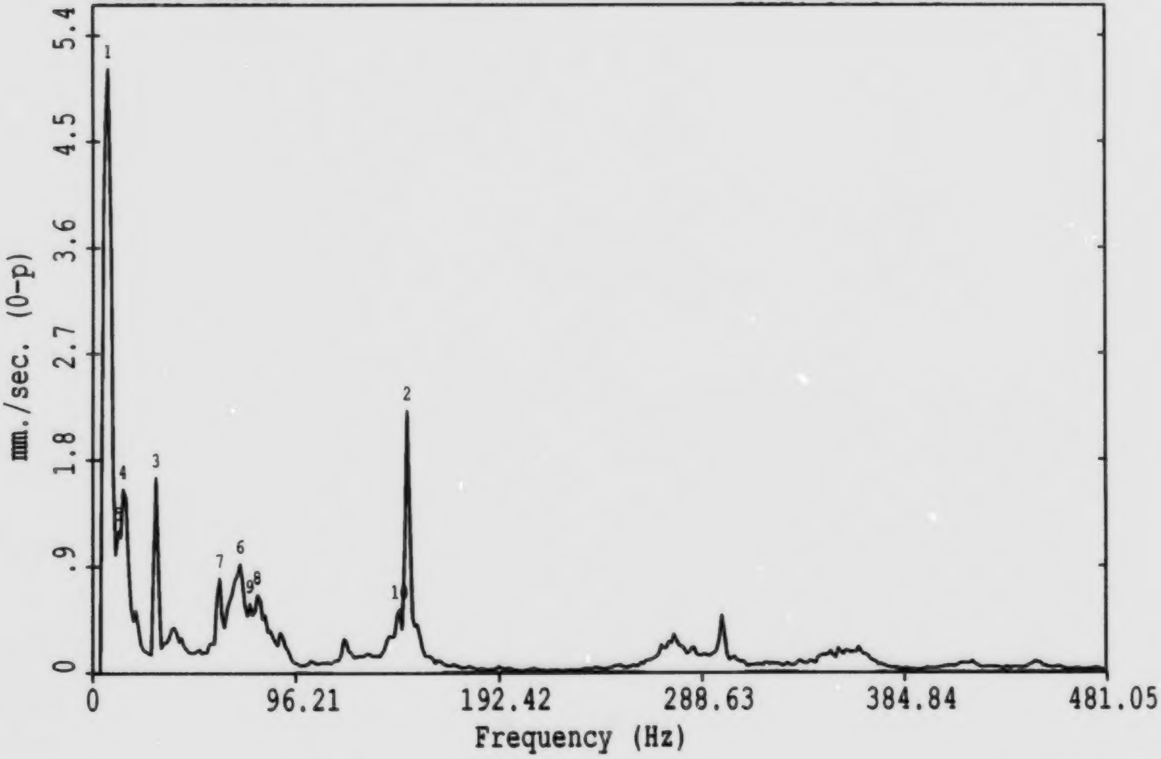


FIGURE 63

PNGS Unit 2 - ECIS Test #1 Moderator Pumpset Vibration

SIGNAL : Pumpset #4 - Motor Casing Velocity E-W
PROCESS CONDITION : Dump Test Loc #2

PEAK NO.	FREQUENCY	AMPLITUDE
1	7.2	19.23
2	60.1	3.07
3	16.8	2.91
4	30.1	2.16
5	21.6	1.88
6	36.1	1.06
7	56.5	0.90
8	149.1	0.78
9	25.3	0.66
10	64.9	0.65

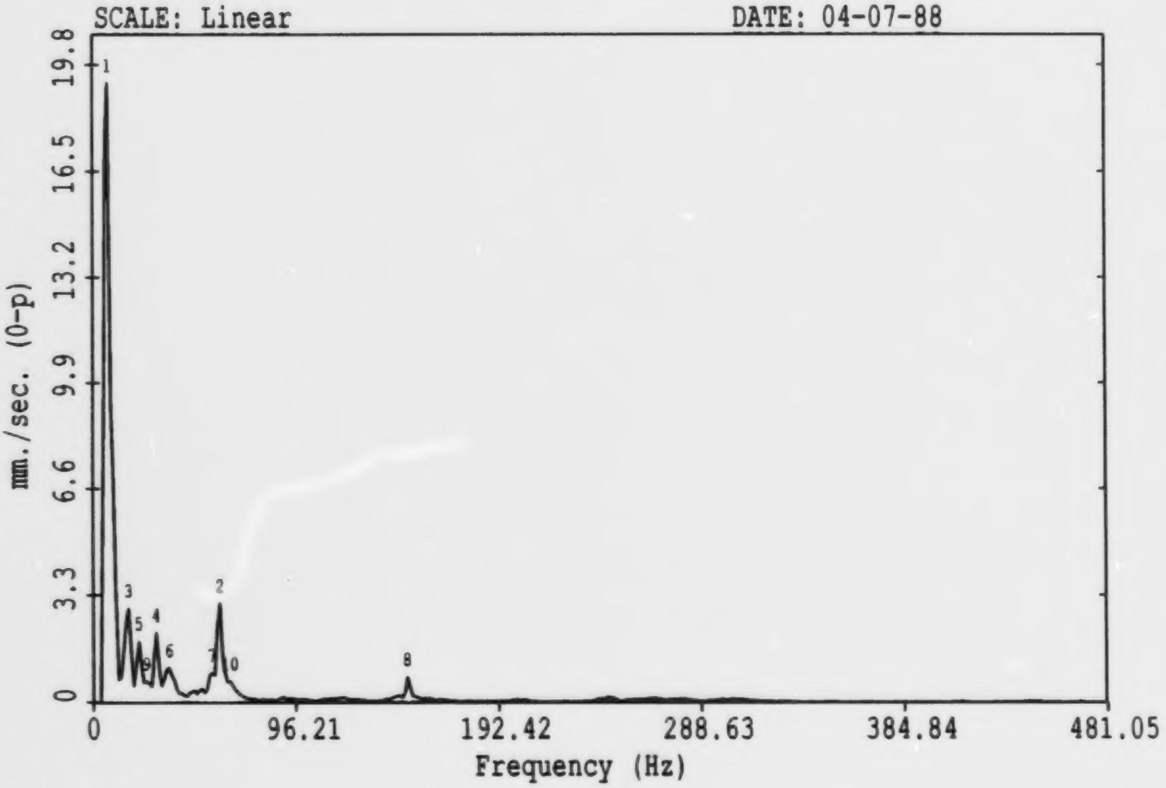


FIGURE 64

PNGS Unit 2 - ECIS Test #1 Moderator Pumpset Vibration

SIGNAL : Pumpset #5 - Motor Casing Vel E-W
PROCESS CONDITION : Dump Test Loc 2

PEAK NO.	FREQUENCY	AMPLITUDE
1	7.2	22.60
2	60.1	4.49
3	149.1	4.34
4	19.2	3.23
5	30.1	2.00
6	34.9	1.68
7	14.4	1.48
8	90.2	1.48
9	145.5	1.37
10	153.9	1.20

SCALE: Linear

DATE: 04-07-88

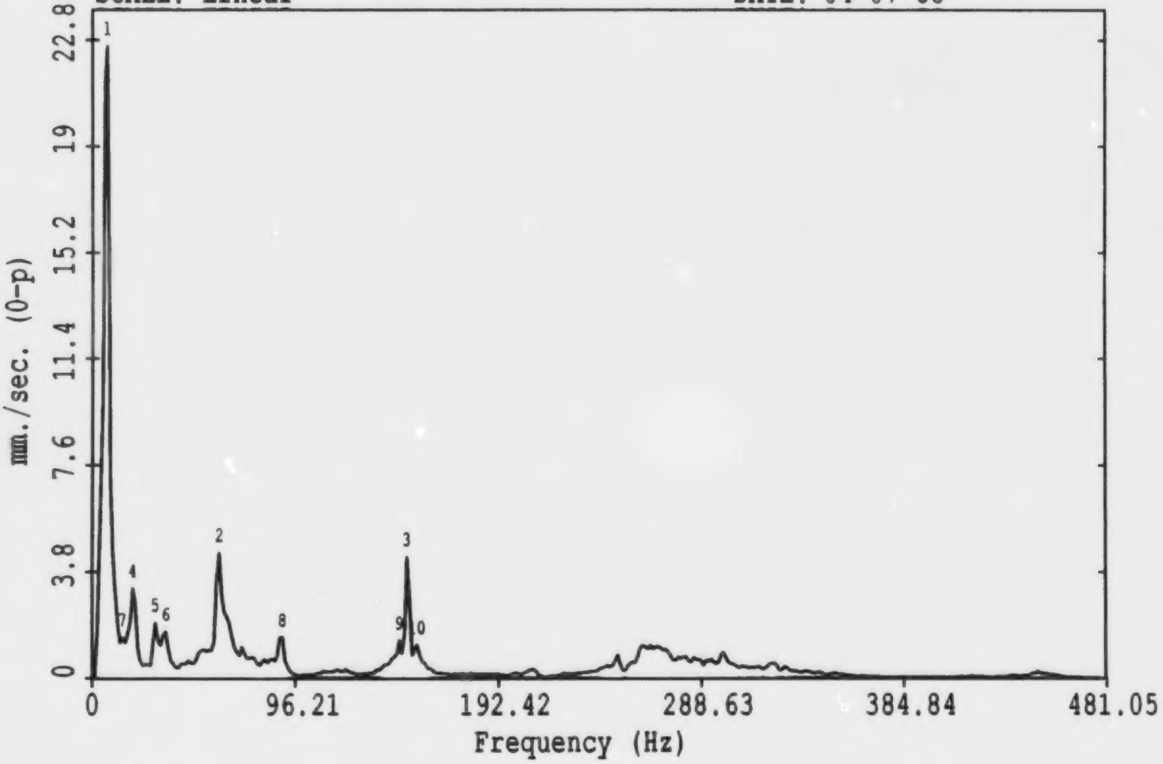


FIGURE 65

PNGS Unit 2 - ECIS Test #1 Moderator Pumpset Vibration

SIGNAL : Pumpset #5 - Motor Casing Vel N-S
PROCESS CONDITION : Dump Test Loc 2

PEAK NO.	FREQUENCY	AMPLITUDE
1	3.6	27.41
2	9.6	12.24
3	149.1	7.10
4	19.2	2.03
5	145.5	1.72
6	153.9	1.70
7	45.7	1.68
8	60.1	1.54
9	55.3	1.45
10	16.8	1.43

SCALE: Linear

DATE: 04-07-88

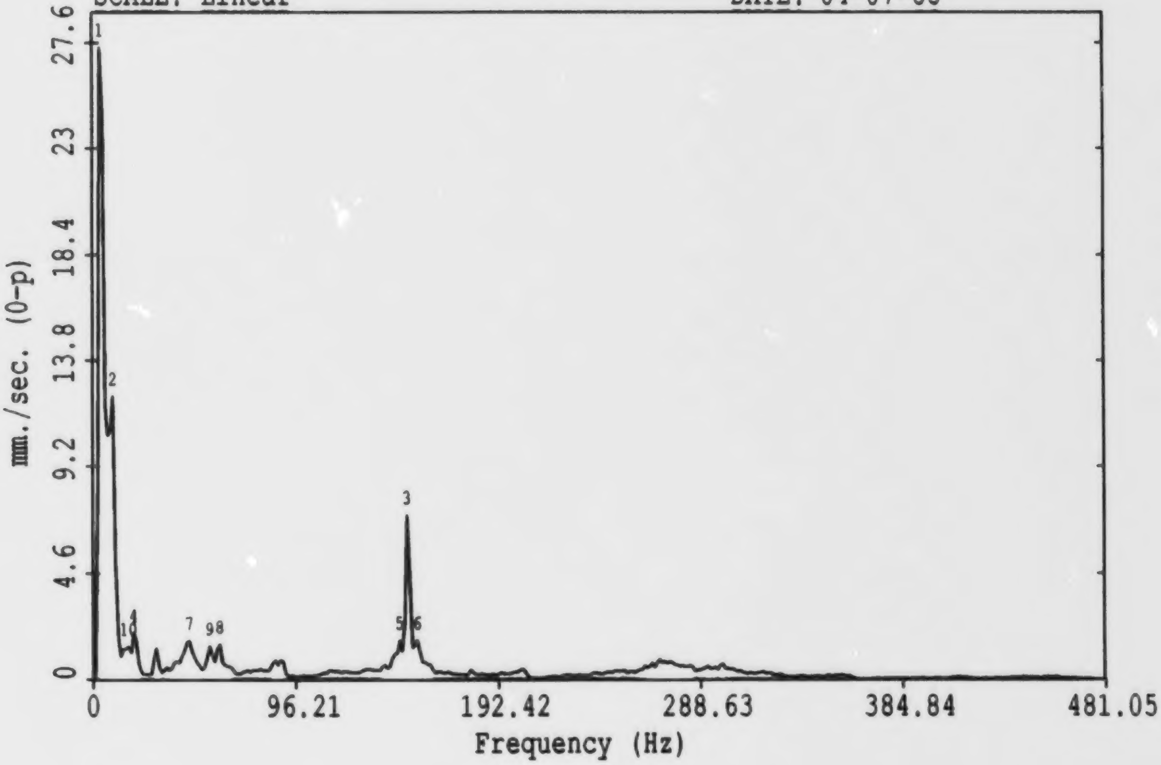


FIGURE 66

PNGS Unit 2 - ECIS Test #1 Moderator Pumpset Vibration

SIGNAL : Pumpset #1 - Pump Shaft Displacement E-W
PROCESS CONDITION : Dump Test Loc 2

PEAK NO.	FREQUENCY	AMPLITUDE
1	149.1	81.38
2	30.1	77.82
3	60.1	19.65
4	90.2	9.82
5	4.8	8.02
6	22.9	7.28
7	145.5	7.19
8	18.0	6.80
9	2.4	6.64
10	80.6	6.44

SCALE: Linear DATE: 04-07-88

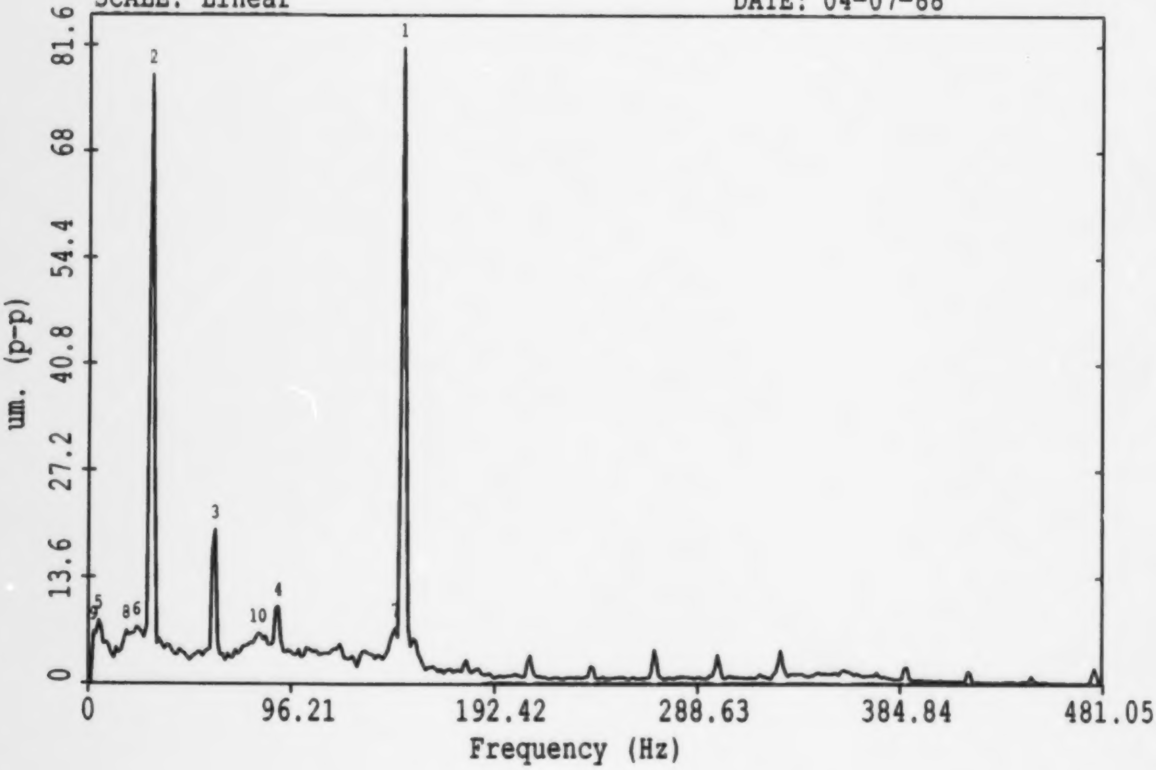


FIGURE 67

PNGS Unit 2 - ECIS Test #1 Moderator Pumpset Vibration

SIGNAL : Pumpset #1 - Pump Shaft Displacement N-S
PROCESS CONDITION : Dump Test Loc 2

PEAK NO.	FREQUENCY	AMPLITUDE
1	30.1	106.50
2	149.1	80.99
3	6.0	17.43
4	60.1	15.63
5	89.0	10.71
6	86.6	8.02
7	145.5	8.00
8	73.4	6.81
9	81.8	6.39
10	19.2	6.07

SCALE: Linear DATE: 04-07-88

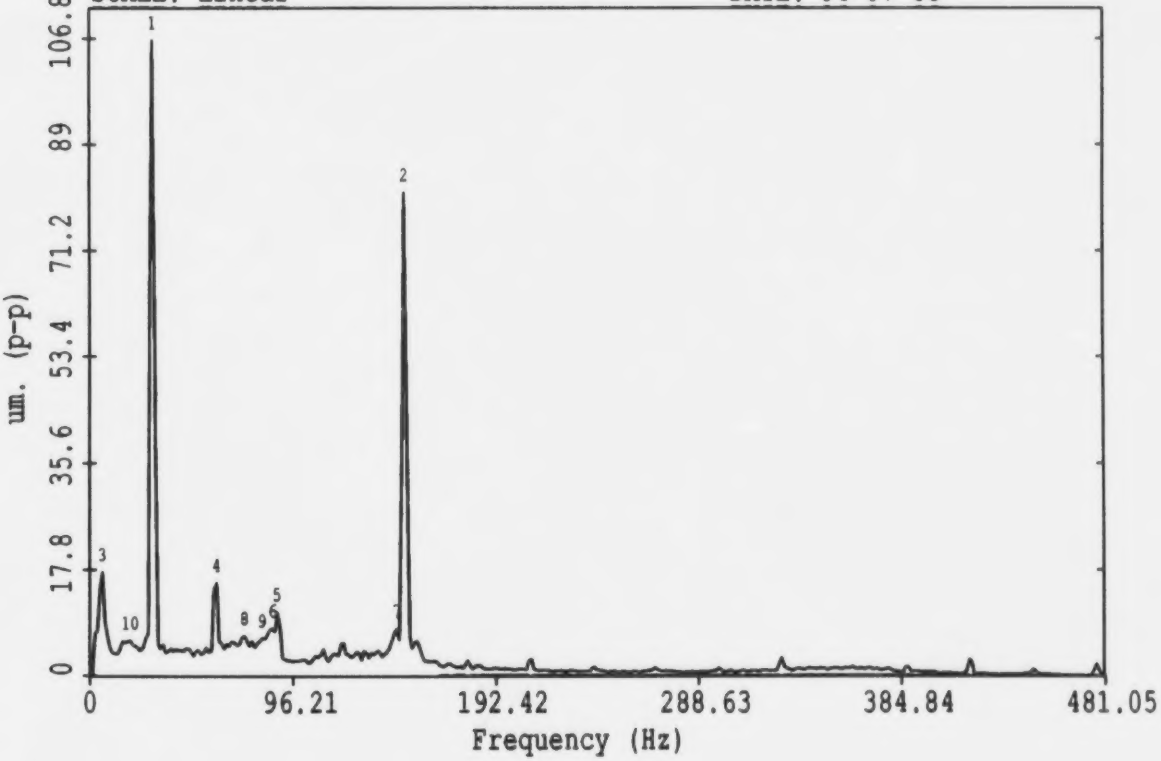


FIGURE 68

PNGS Unit 2 - ECIS Test #1 Moderator Pumpset Vibration

SIGNAL : Pumpset #2 - Pump Shaft Displacement E-W
PROCESS CONDITION : Dump Test Loc 2

PEAK NO.	FREQUENCY	AMPLITUDE
1	30.1	142.60
2	149.1	63.55
3	60.1	21.71
4	145.5	16.65
5	153.9	14.24
6	298.3	13.33
7	119.1	11.93
8	89.0	11.86
9	179.2	11.69
10	2.4	8.99

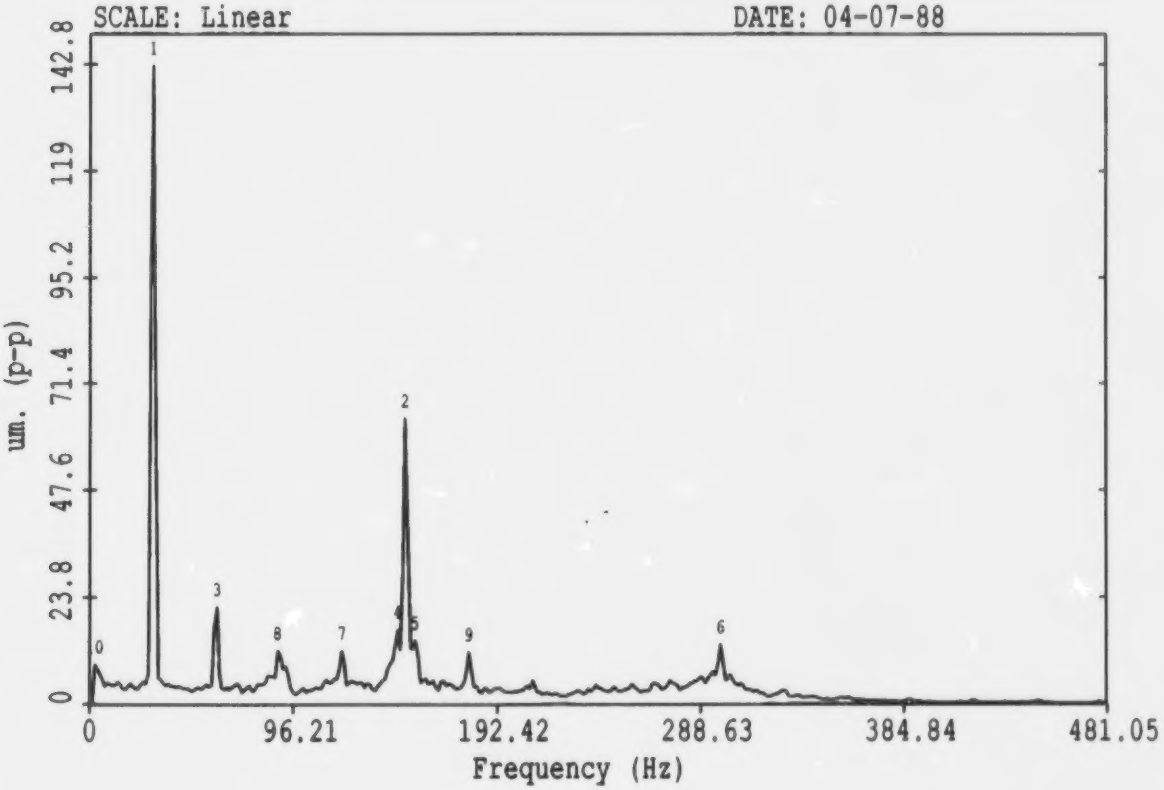
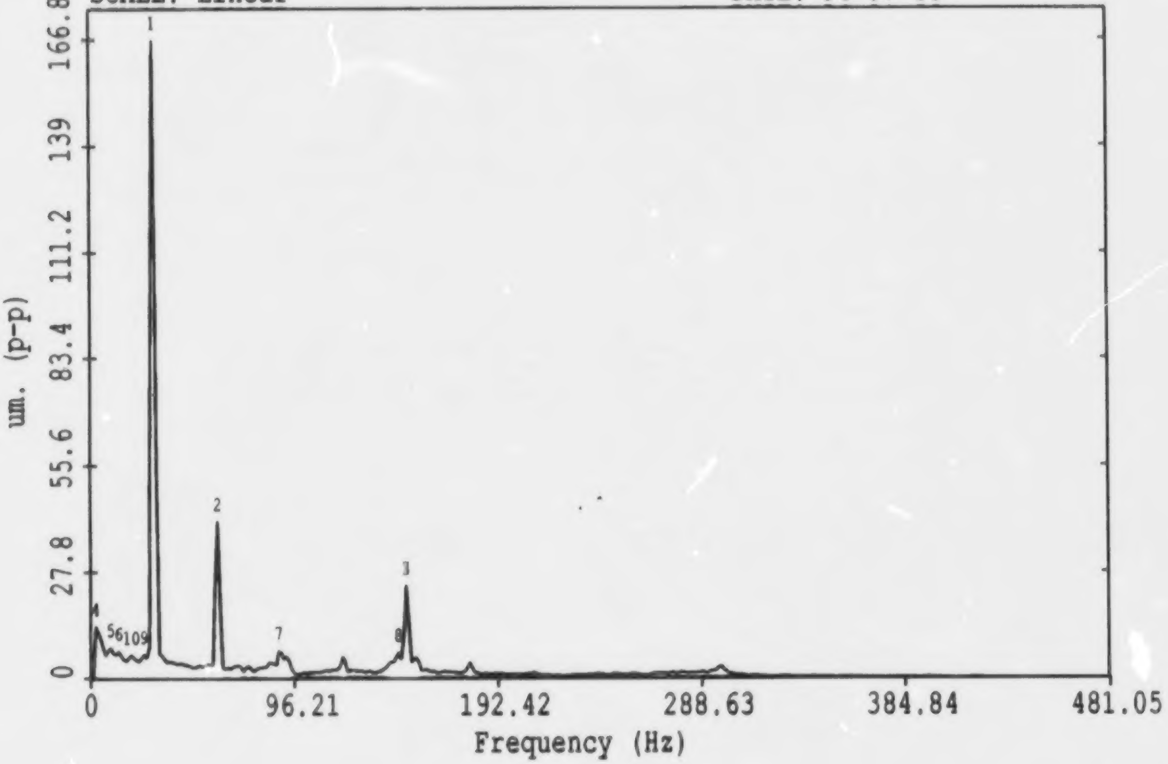


FIGURE 69

PNGS Unit 2 - ECIS Test #1 Moderator Pumpset Vibration

SIGNAL : Pumpset #2 - Pump Shaft Displacement N-S
PROCESS CONDITION : Dump Test Loc 2

PEAK NO.	FREQUENCY	AMPLITUDE
1	30.1	166.60
2	60.1	40.94
3	149.1	24.23
4	2.4	13.59
5	9.6	8.07
6	13.2	7.15
7	89.0	7.10
8	145.5	6.78
9	25.3	6.22
10	19.2	6.08



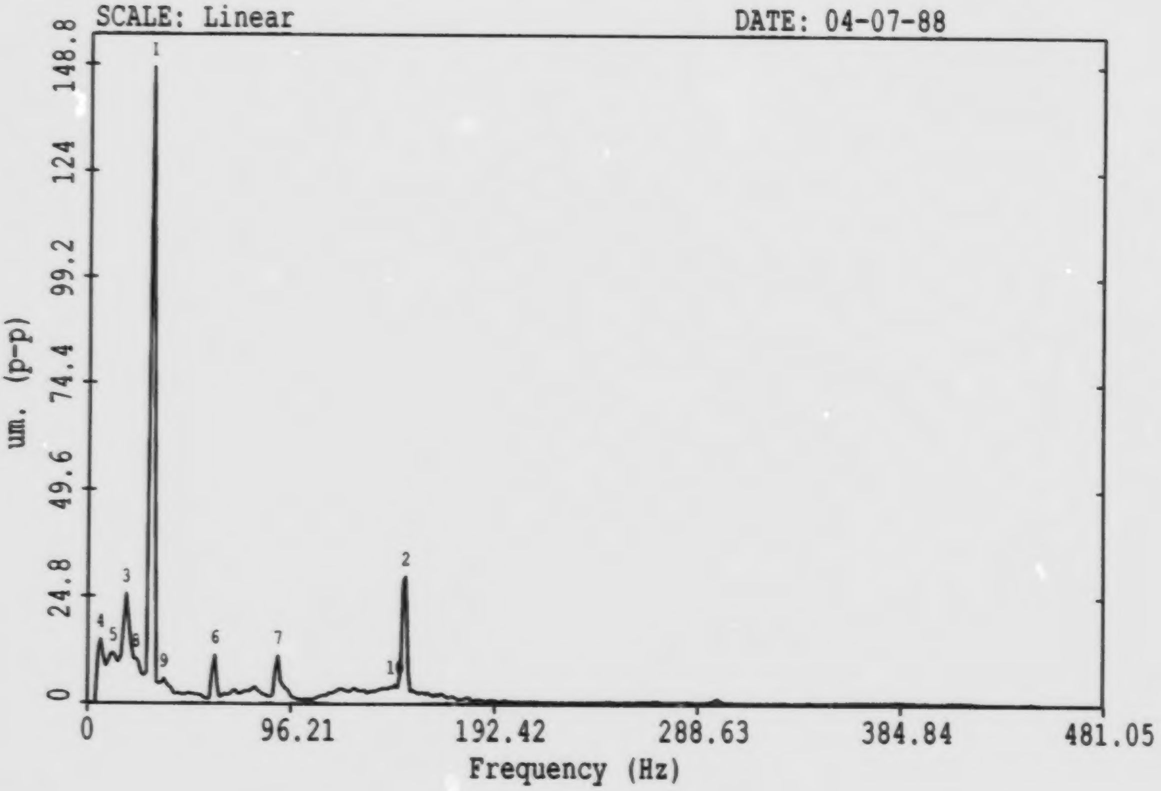
SCALE: Linear DATE: 04-07-88

FIGURE 70

PNGS Unit 2 - ECIS Test #1 Moderator Pumpset Vibration

SIGNAL : Pumpset #3 - Pump Shaft Displacement E-W
PROCESS CONDITION : Dump Test Loc #2

PEAK NO.	FREQUENCY	AMPLITUDE
1	30.1	148.30
2	150.3	29.70
3	18.0	25.60
4	6.0	14.94
5	12.0	11.79
6	60.1	11.33
7	90.2	11.22
8	22.9	10.40
9	36.1	5.79
10	145.5	4.53



SCALE: Linear

DATE: 04-07-88

FIGURE 71

PNGS Unit 2 - ECIS Test #1 Moderator Pumpset Vibration

SIGNAL : Pumpset #4 - Pump Shaft Displacement E-W
PROCESS CONDITION : Dump Test Loc #2

PEAK NO.	FREQUENCY	AMPLITUDE
1	9.6	23.92
2	60.1	14.14
3	7.2	14.10
4	149.1	12.53
5	16.8	6.84
6	21.6	5.53
7	14.4	4.92
8	64.9	3.76
9	30.1	3.32
10	145.5	2.89

SCALE: Linear

DATE: 04-07-88

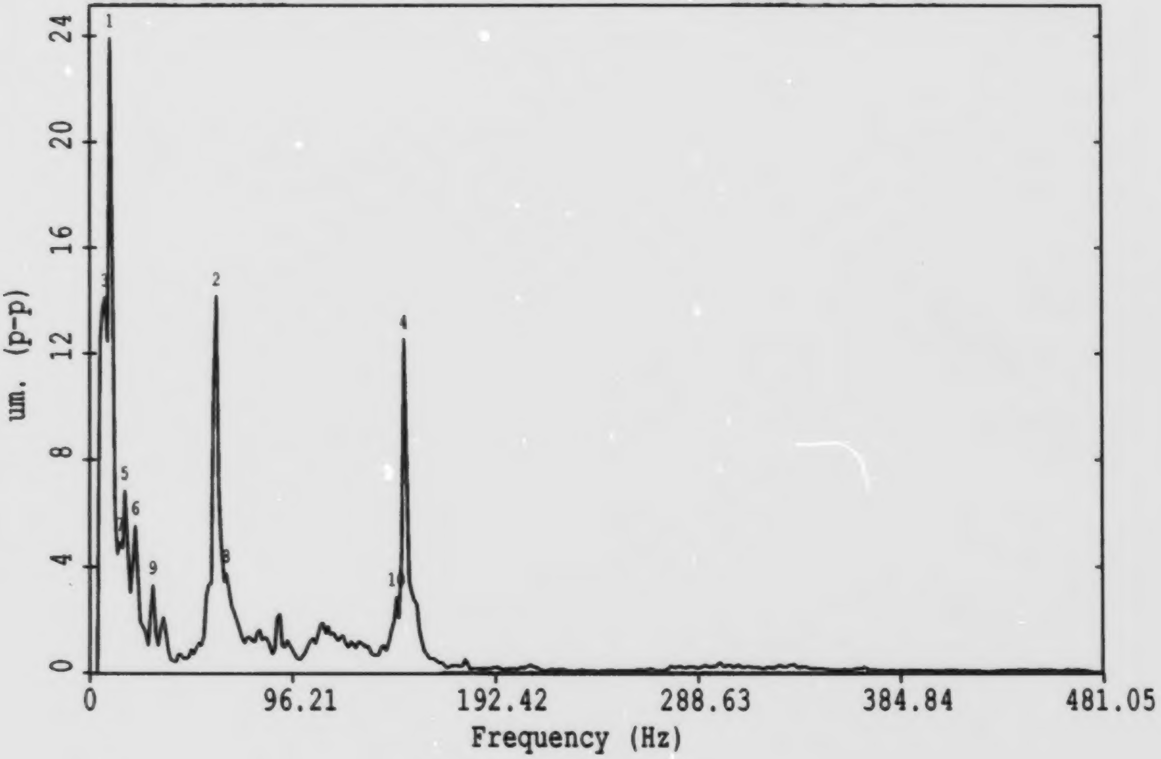


FIGURE 72

PNGS Unit 2 - ECIS Test #1 Moderator Pumpset Vibration

SIGNAL : Pumpset #5 - Pump Shaft Displacement E-W
PROCESS CONDITION : Dump Test Loc 2

PEAK NO.	FREQUENCY	AMPLITUDE
1	149.1	128.60
2	30.1	100.70
3	145.5	36.79
4	153.9	35.54
5	3.6	22.12
6	7.2	21.74
7	60.1	19.25
8	89.0	11.41
9	55.3	10.29
10	134.7	10.05

SCALE: Linear

DATE: 04-07-88

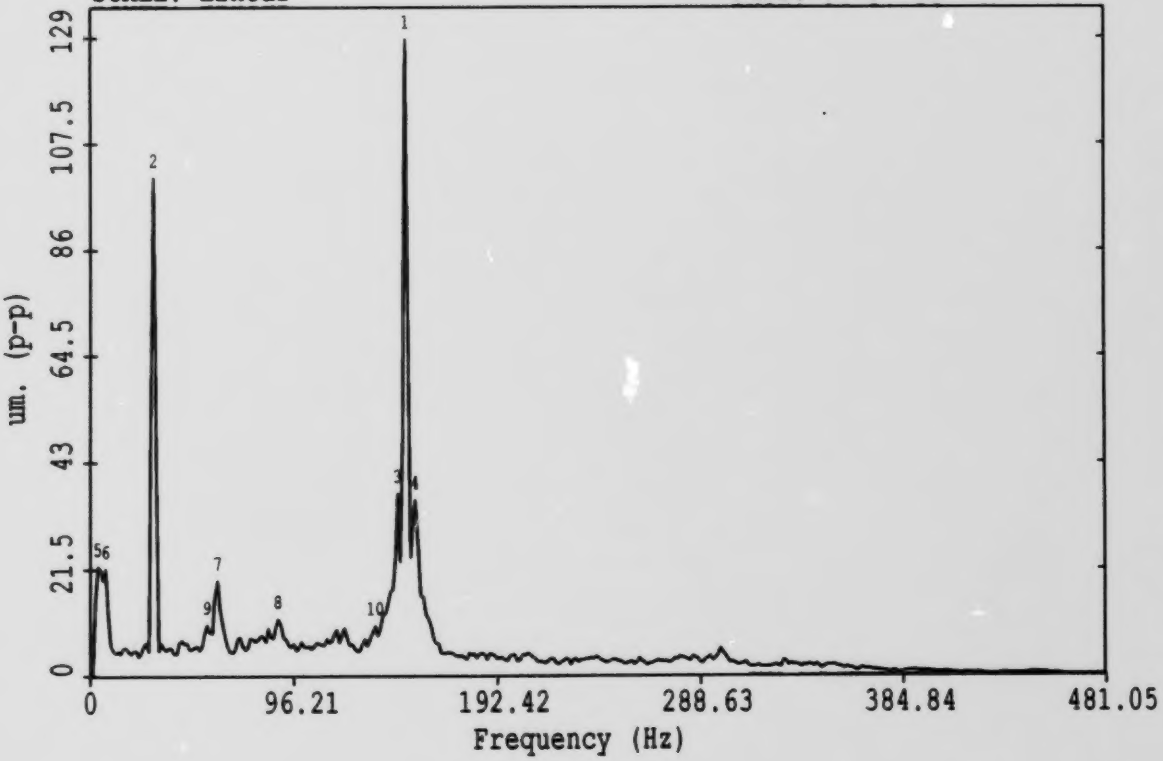


FIGURE 73

PNGS Unit 2 - ECIS Test #1 Moderator Pumpset Vibration

SIGNAL : Pumpset #5 - Pump Shaft Displacement N-S
PROCESS CONDITION : Dump Test Loc 2

PEAK NO.	FREQUENCY	AMPLITUDE
1	30.1	97.54
2	149.1	96.48
3	145.5	30.19
4	153.9	27.04
5	60.1	22.43
6	7.2	21.65
7	90.2	15.61
8	63.7	10.94
9	120.3	8.23
10	134.7	8.02

SCALE: Linear DATE: 04-07-88

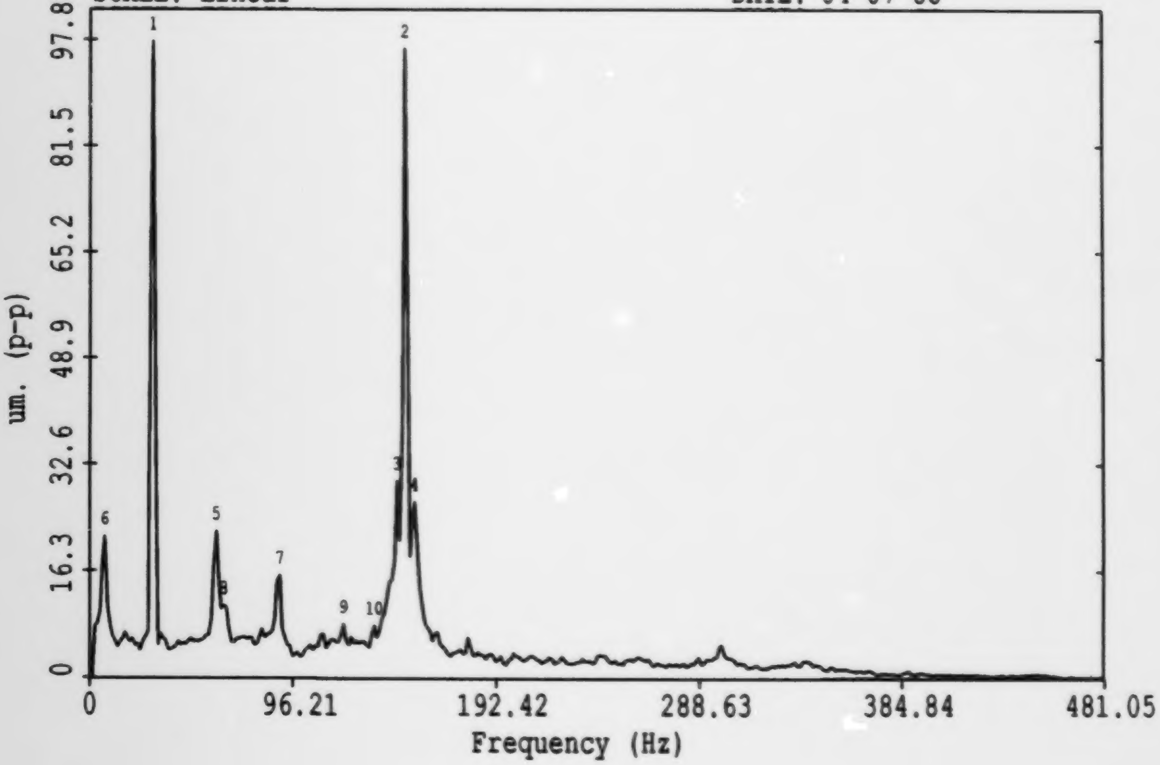


FIGURE 74

PNGS Unit 2 - ECIS Test #1 Moderator Pumpset Vibration

SIGNAL : Expansion Joint #3 Vertical Velocity
PROCESS CONDITION : Dump Test Loc #2

PEAK NO.	FREQUENCY	AMPLITUDE
1	4.8	9.44
2	15.6	5.05
3	149.1	1.81
4	60.1	1.33
5	30.1	1.25
6	50.5	0.93
7	44.5	0.68
8	56.5	0.64
9	25.3	0.62
10	38.5	0.60

SCALE: Linear

DATE: 04-07-88

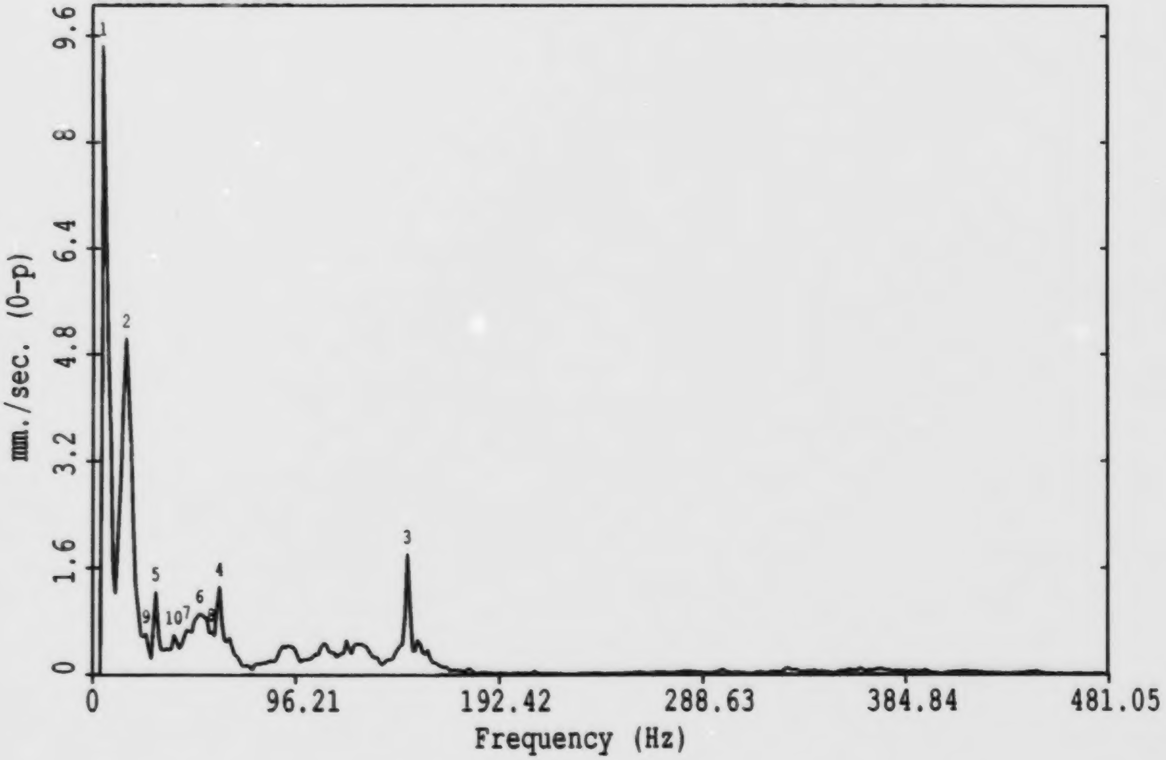


FIGURE 75

PNGS Unit 2 - ECIS Test #1 Moderator Pumpset Vibration

SIGNAL : Expansion Joint #3 Horizontal Velocity
PROCESS CONDITION : Dump Test Loc #2

PEAK NO.	FREQUENCY	AMPLITUDE
1	4.8	9.27
2	18.0	4.61
3	15.6	4.34
4	149.1	2.65
5	60.1	1.94
6	90.2	1.84
7	64.9	1.59
8	68.6	1.23
9	78.2	1.20
10	30.1	1.20

SCALE: Linear DATE: 04-07-88

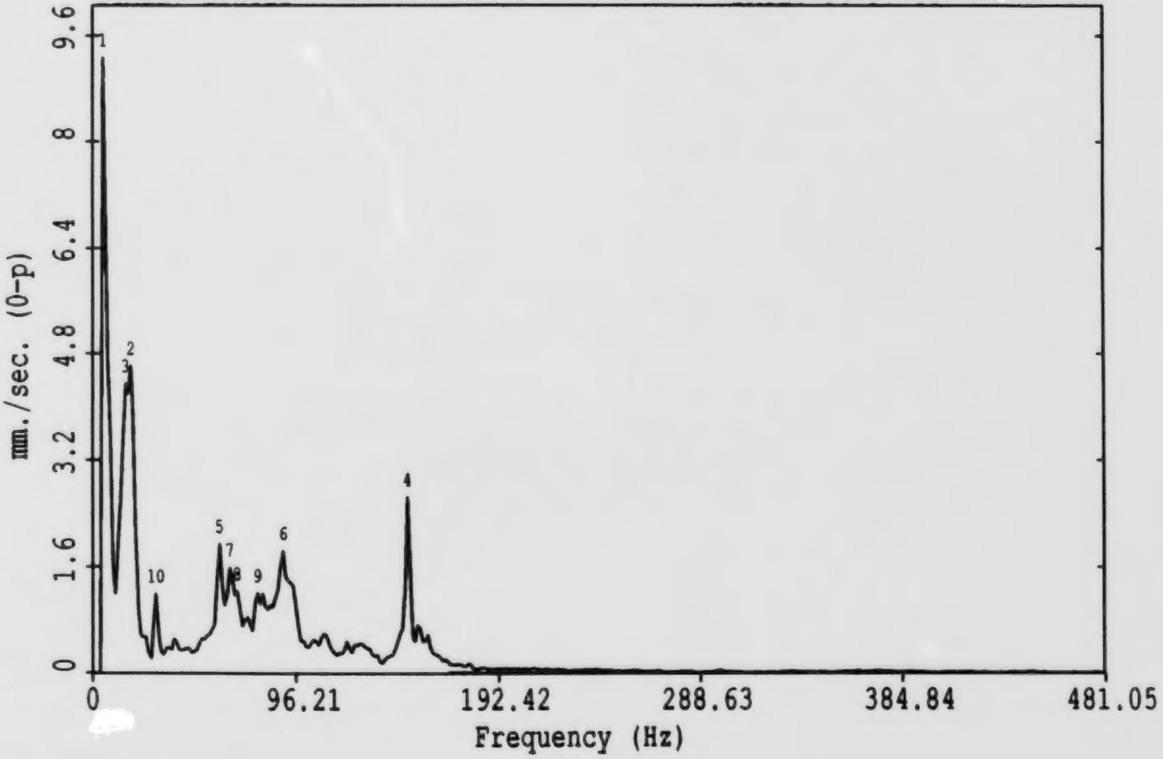


FIGURE 76

PNGS Unit 2 - ECIS Test #1 Moderator Pumpset Vibration

SIGNAL : Expansion Joint #3 Axial Velocity
PROCESS CONDITION : Dump Test Loc #2

PEAK NO.	FREQUENCY	AMPLITUDE
1	6.0	8.02
2	30.1	6.59
3	19.2	6.07
4	15.6	5.73
5	149.1	3.05
6	25.3	1.73
7	50.5	1.66
8	60.1	1.32
9	64.9	0.69
10	33.7	0.66

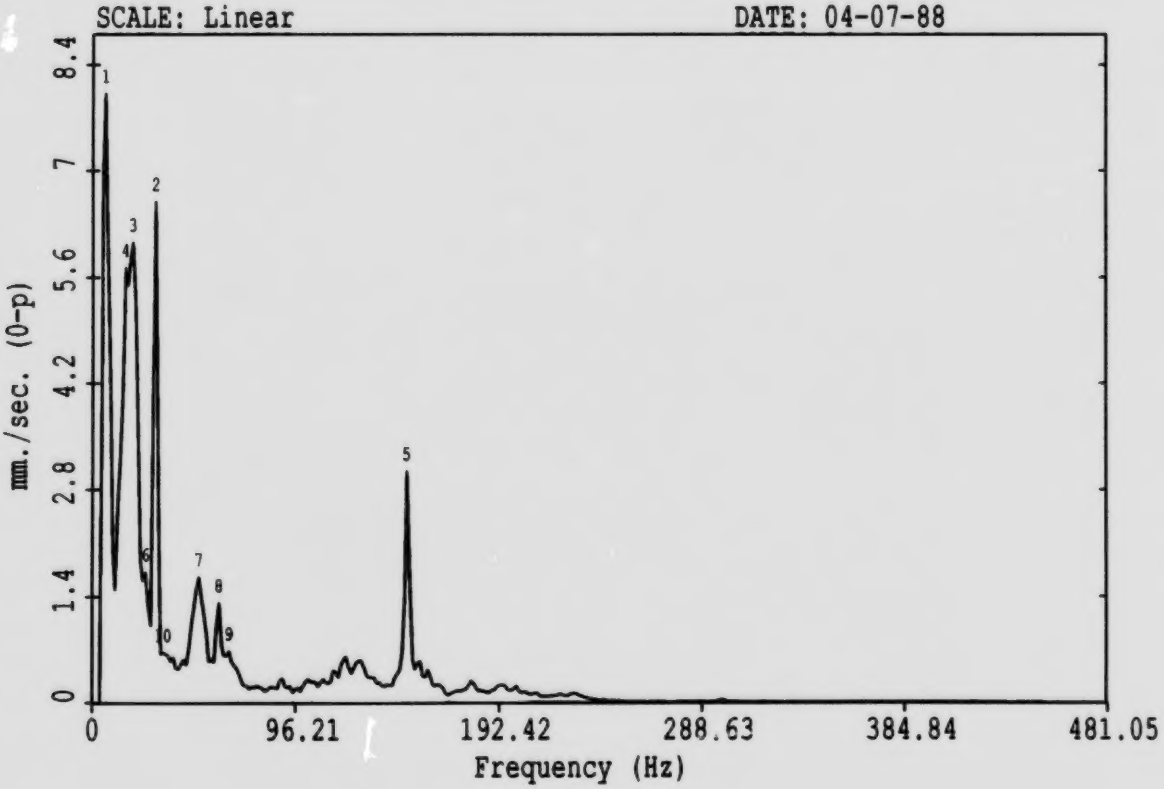


FIGURE 77

PNGS Unit 2 - ECIS Test #1 Moderator Pumpset Vibration

SIGNAL : Expansion Joint #4 Vertical Velocity
PROCESS CONDITION : Dump Test Loc #2

PEAK NO.	FREQUENCY	AMPLITUDE
1	4.8	25.71
2	16.8	11.67
3	9.6	11.26
4	21.6	3.71
5	30.1	2.13
6	33.7	1.42
7	25.3	0.99
8	149.1	0.91
9	38.5	0.61

SCALE: Linear

DATE: 04-07-88

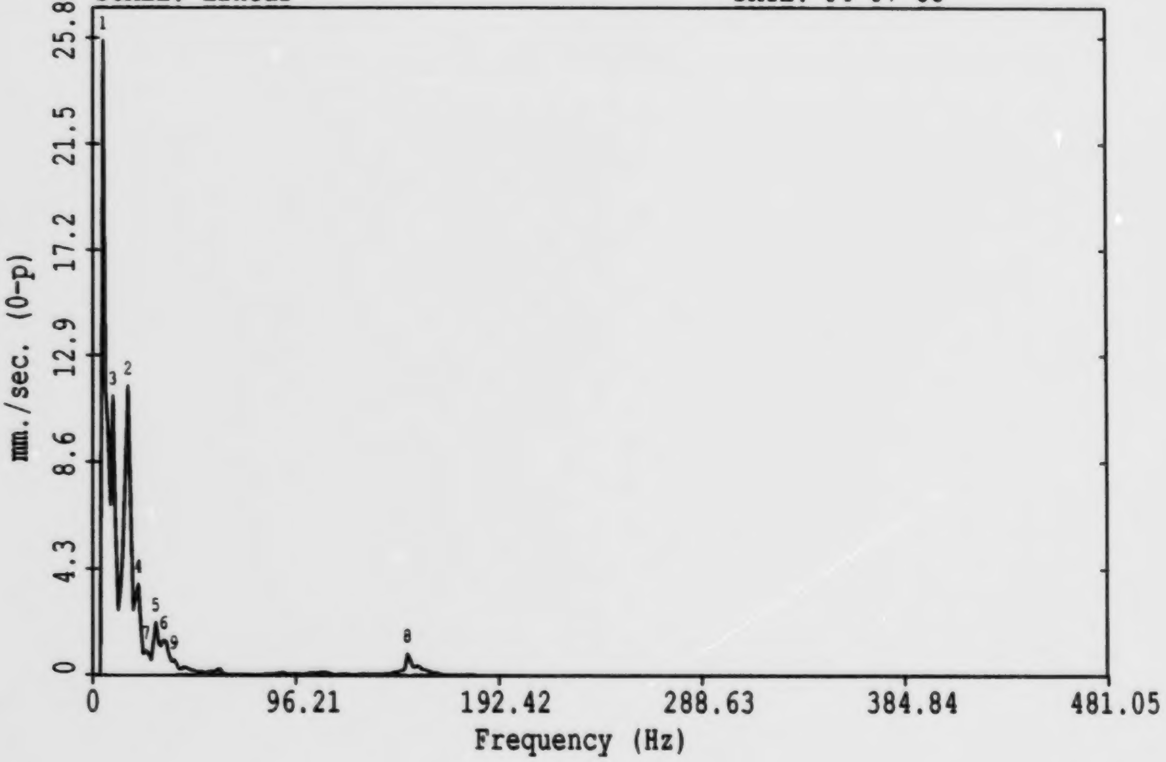


FIGURE 78

PNGS Unit 2 - ECIS Test #1 Moderator Pumpset Vibration

SIGNAL : Expansion Joint #4 Horizontal Velocity
PROCESS CONDITION : Dump Test Loc #2

PEAK NO.	FREQUENCY	AMPLITUDE
1	4.8	25.86
2	9.6	12.71
3	15.6	8.86
4	21.6	4.67
5	28.9	2.67
6	44.5	1.89
7	71.0	1.87
8	56.5	1.86
9	149.1	1.84
10	34.9	1.80

SCALE: Linear

DATE: 04-07-88

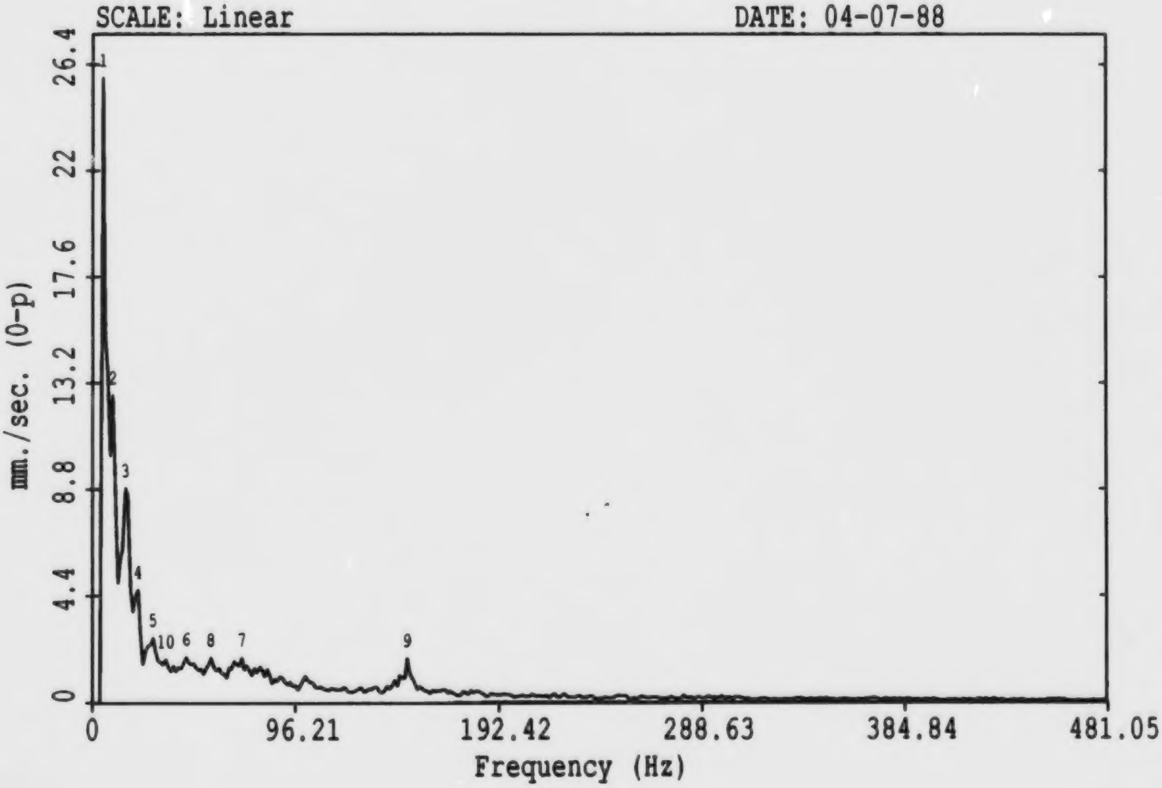


FIGURE 79

PNGS Unit 2 - ECIS Test #1 Moderator Pumpset Vibration

SIGNAL : Expansion Joint #4 Axial Velocity
PROCESS CONDITION : Dump Test Loc #2

PEAK NO.	FREQUENCY	AMPLITUDE
1	4.8	9.75
2	9.6	6.64
3	19.2	4.84
4	60.1	4.20
5	16.8	4.11
6	149.1	1.77
7	30.1	1.62
8	55.3	1.27
9	25.3	1.22
10	34.9	1.14

SCALE: Linear DATE: 04-07-88

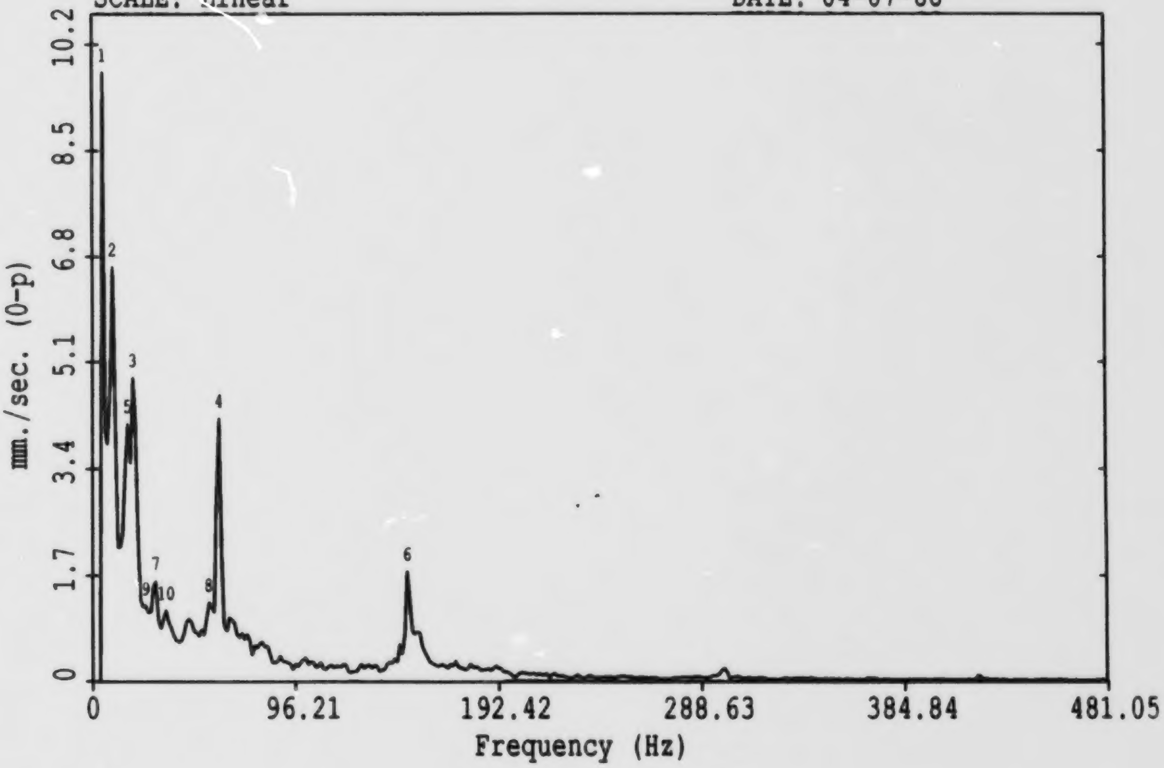


FIGURE 80

PNGS Unit 2 - ECIS Test #2 Moderator Pumpset Vibration

SIGNAL : Pumpset #1 - Motor Casing Vel E-W
PROCESS CONDITION : Dump Test

PEAK NO.	FREQUENCY	AMPLITUDE
1	6.0	4.91
2	30.1	4.11
3	8.4	3.36
4	149.1	0.98
5	19.2	0.73
6	119.1	0.60
7	16.8	0.60
8	89.0	0.57
9	25.3	0.51
10	111.8	0.38

SCALE: Linear DATE: 18-07-88

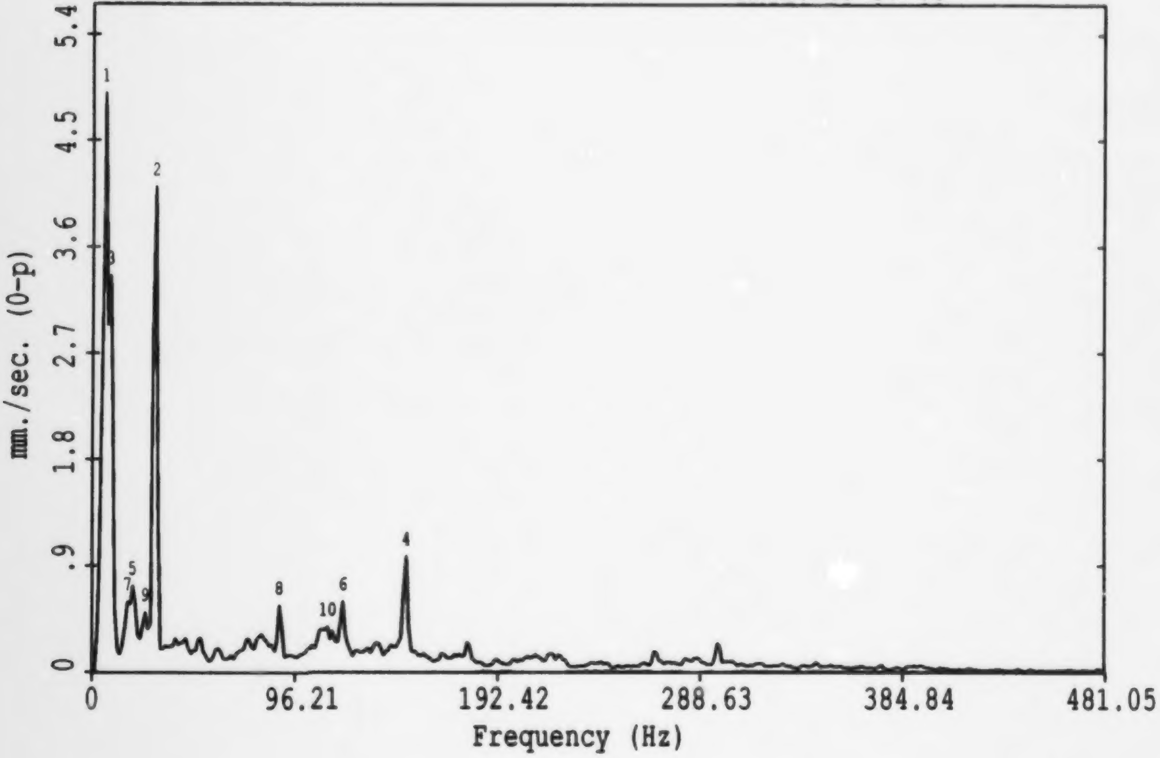


FIGURE 81

PNGS Unit 2 - ECIS Test #2 Moderator Pumpset Vibration

SIGNAL : Pumpset #1 - Motor Casing Vel N-S
PROCESS CONDITION : Dump Test

PEAK NO.	FREQUENCY	AMPLITUDE
1	6.0	5.09
2	30.1	2.26
3	149.1	0.82
4	64.9	0.73
5	60.1	0.54
6	12.0	0.49
7	74.6	0.44
8	72.2	0.43
9	77.0	0.41
10	119.1	0.38

SCALE: Linear DATE: 18-07-88

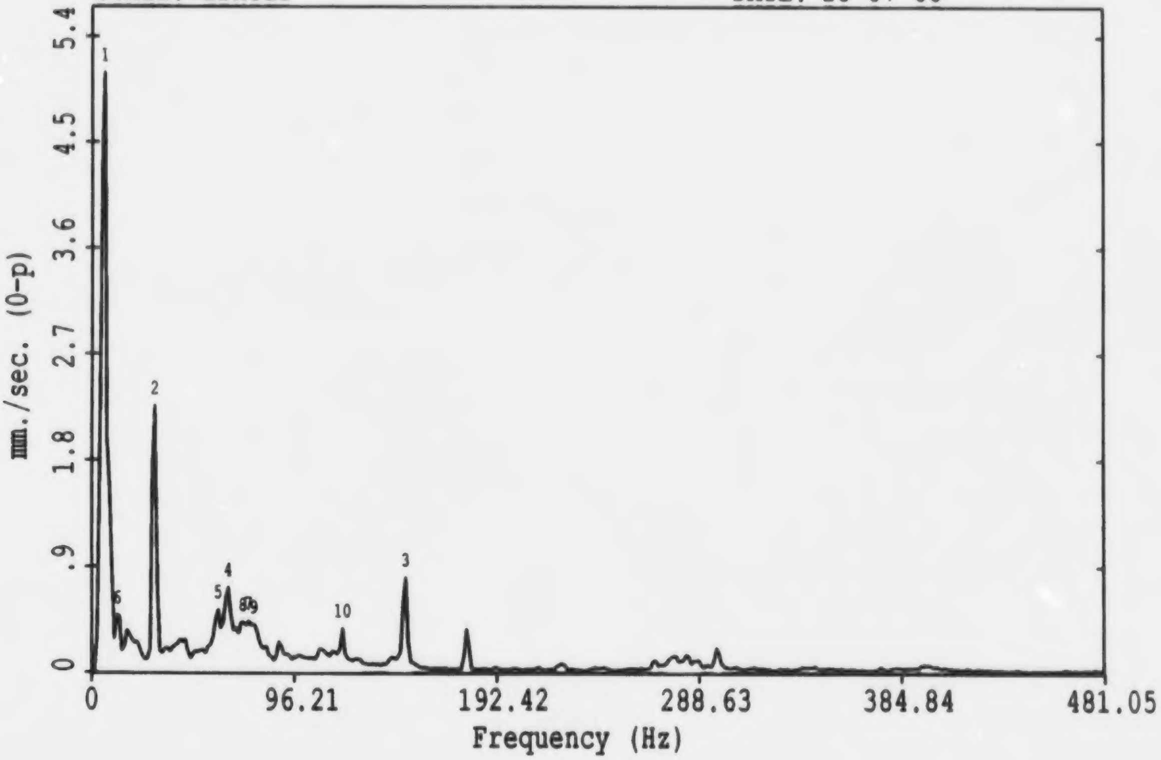


FIGURE 82

PNGS Unit 2 - ECIS Test #2 Moderator Pumpset Vibration

SIGNAL : Pumpset #2 - Motor Casing Vel E-W
PROCESS CONDITION : Dump Test

PEAK NO.	FREQUENCY	AMPLITUDE
1	30.1	2.28
2	9.6	1.85
3	6.0	1.51
4	149.1	0.89
5	119.1	0.76
6	125.1	0.52
7	110.6	0.46
8	44.5	0.41
9	135.9	0.41
10	89.0	0.39

SCALE: Linear

DATE: 18-07-88

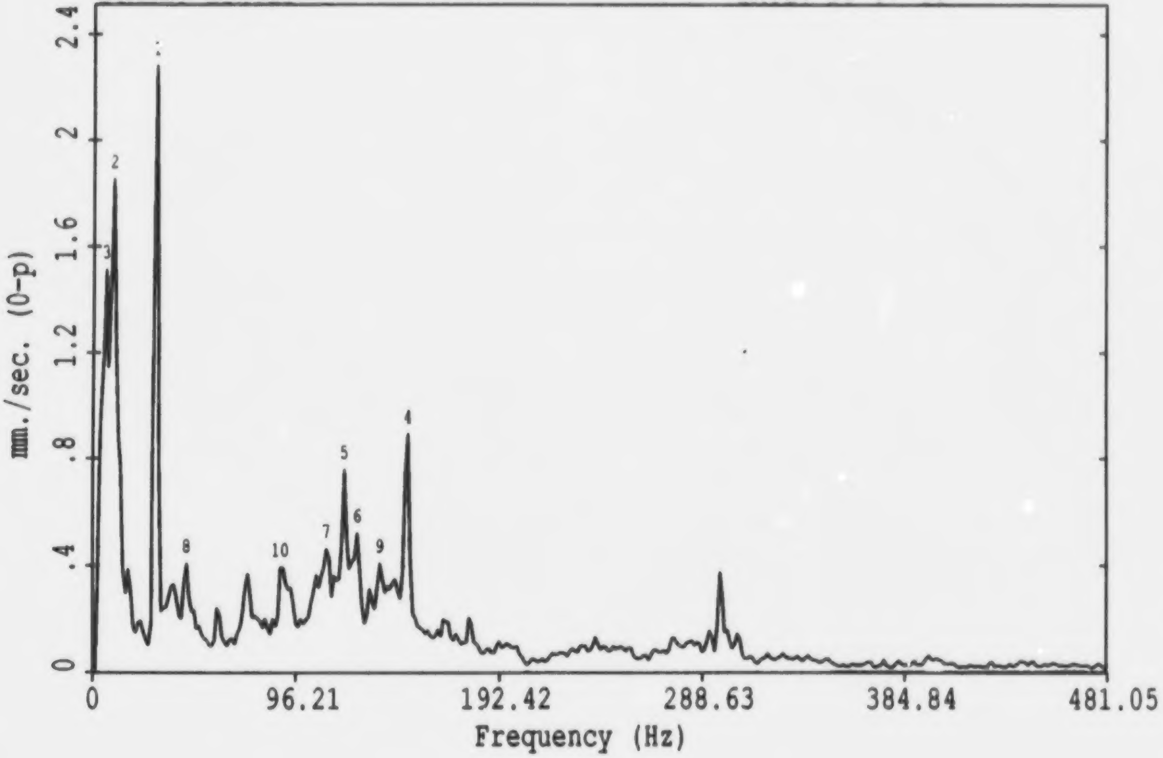


FIGURE 83

PNGS Unit 2 - ECIS Test #2 Moderator Pumpset Vibration

SIGNAL : Pumpset #2 - Motor Casing Vel N-S
PROCESS CONDITION : Dump Test

PEAK NO.	FREQUENCY	AMPLITUDE
1	6.0	5.51
2	30.1	2.79
3	58.9	0.64
4	149.1	0.54
5	89.0	0.52
6	81.8	0.47
7	67.3	0.43
8	16.8	0.40
9	72.2	0.37
10	74.6	0.36

SCALE: Linear DATE: 18-07-88

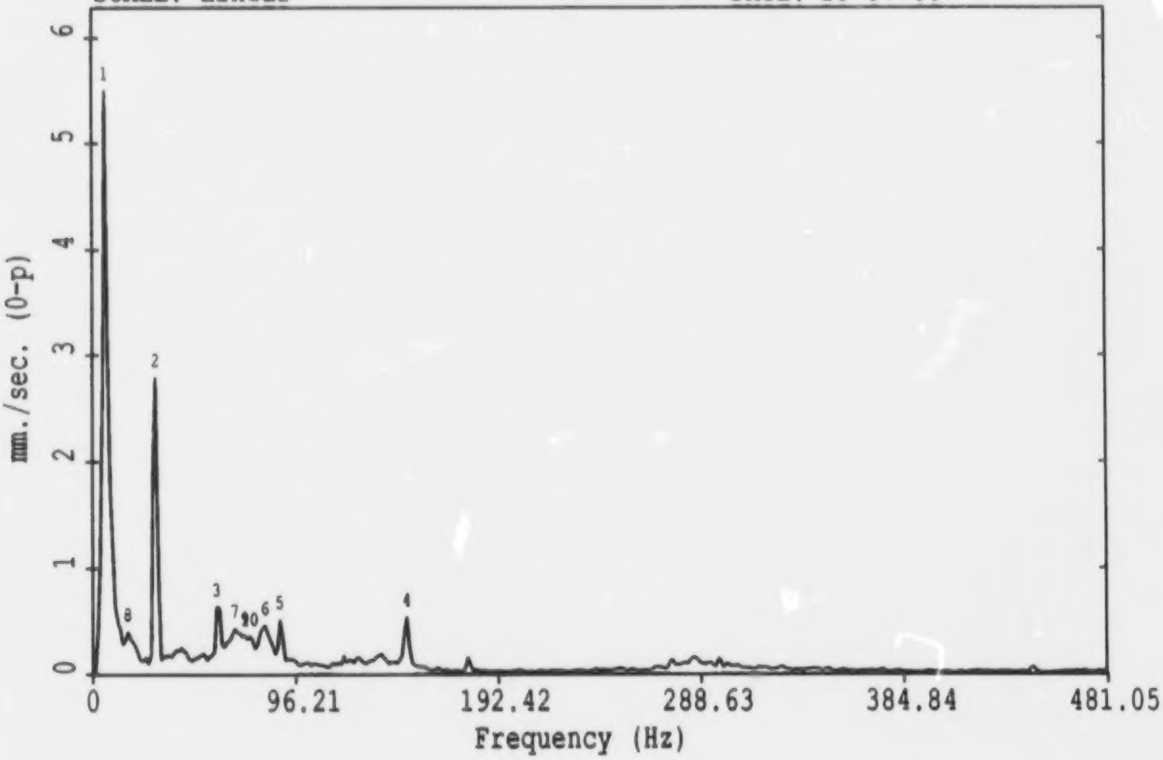


FIGURE 84

PNGS Unit 2 - ECIS Test #2 Moderator Pumpset Vibration

SIGNAL : Pumpset #3 - Motor Casing Velocity E-W
PROCESS CONDITION : Dump Test

PEAK NO.	FREQUENCY	AMPLITUDE
1	6.0	6.61
2	30.1	2.21
3	149.1	1.84
4	9.6	1.72
5	16.8	1.00
6	89.0	0.79
7	119.1	0.78
8	297.1	0.52
9	141.9	0.49
10	125.1	0.32

SCALE: Linear

DATE: 18-07-88

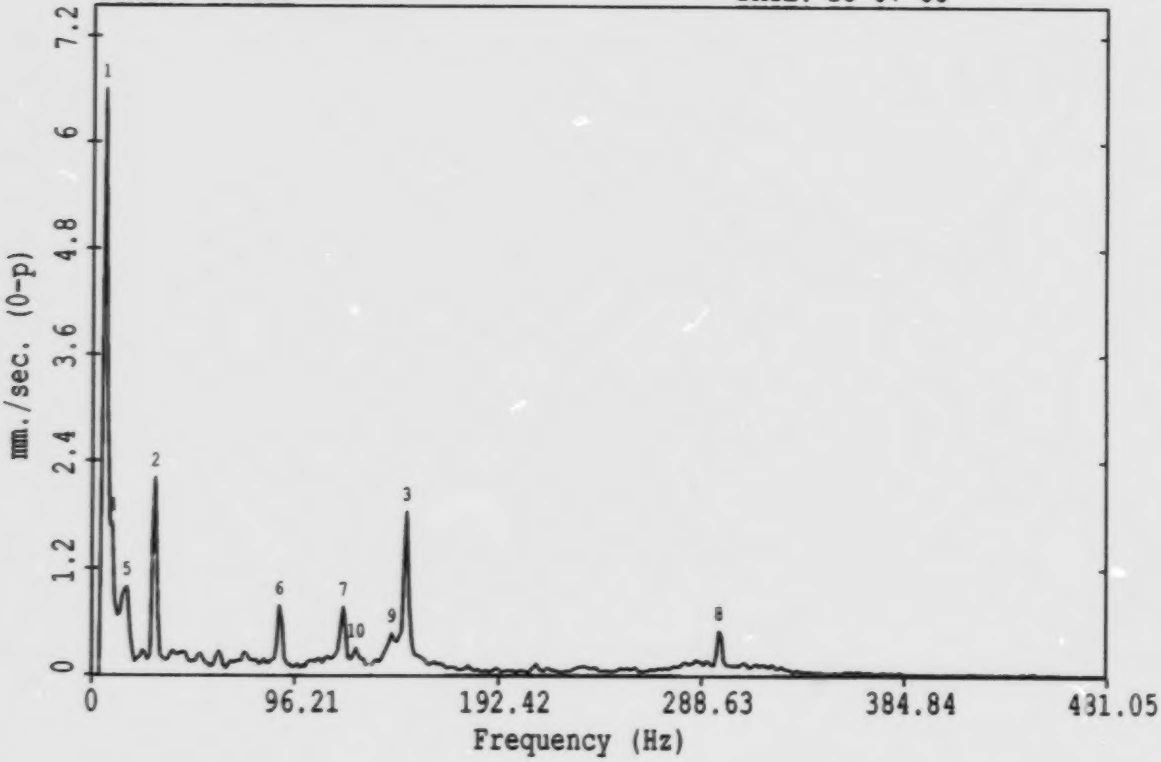


FIGURE 85

PNGS Unit 2 - ECIS Test #2 Moderator Pumpset Vibration

SIGNAL : Pumpset #3 - Motor Casing Velocity N-S
PROCESS CONDITION : Dump Test

PEAK NO.	FREQUENCY	AMPLITUDE
1	8.4	2.17
2	30.1	2.05
3	149.1	0.55
4	60.1	0.50
5	80.6	0.45
6	16.8	0.43
7	13.2	0.42
8	84.2	0.40
9	297.1	0.34
10	71.0	0.33

SCALE: Linear DATE: 18-07-88

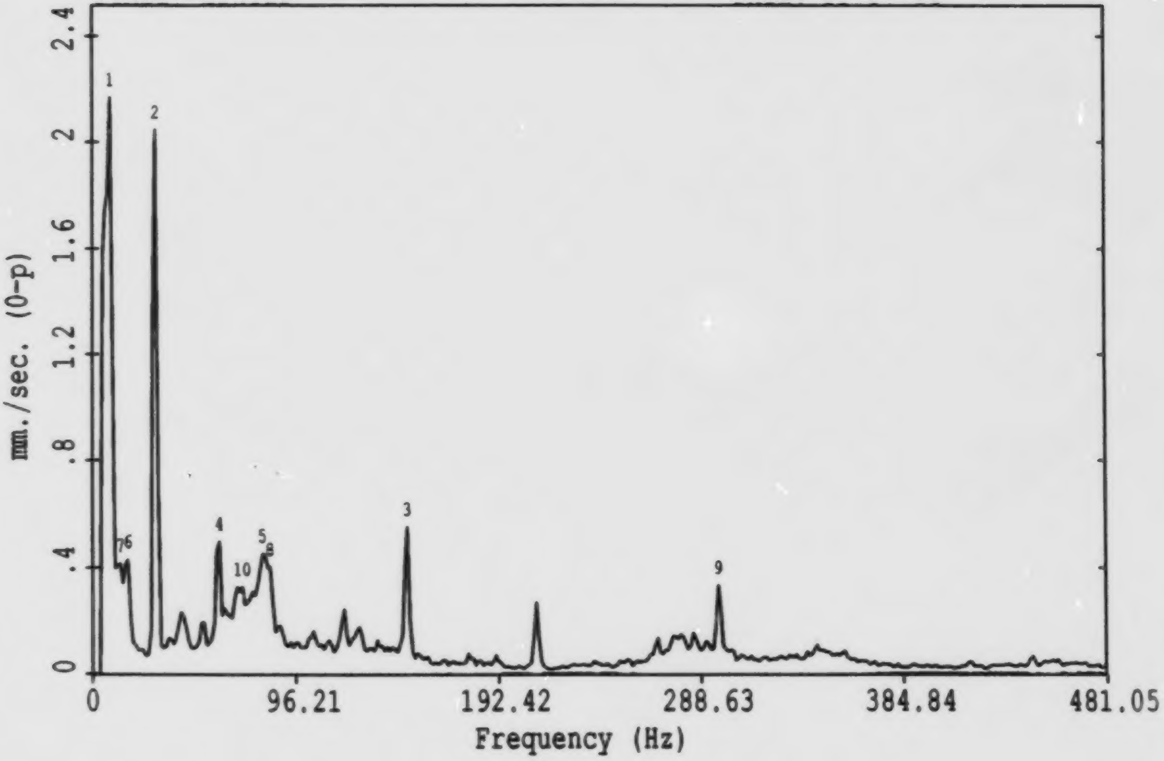


FIGURE 86

PNGS Unit 2 - ECIS Test #2 Moderator Pumpset Vibration

SIGNAL : Pumpset #4 - Motor Casing Velocity E-W
PROCESS CONDITION : Dump Test

PEAK NO.	FREQUENCY	AMPLITUDE
1	7.2	11.17
2	30.1	1.37
3	16.8	1.31
4	68.6	0.36
5	60.1	0.33
6	20.4	0.30
7	149.1	0.27

SCALE: Linear DATE: 18-07-88

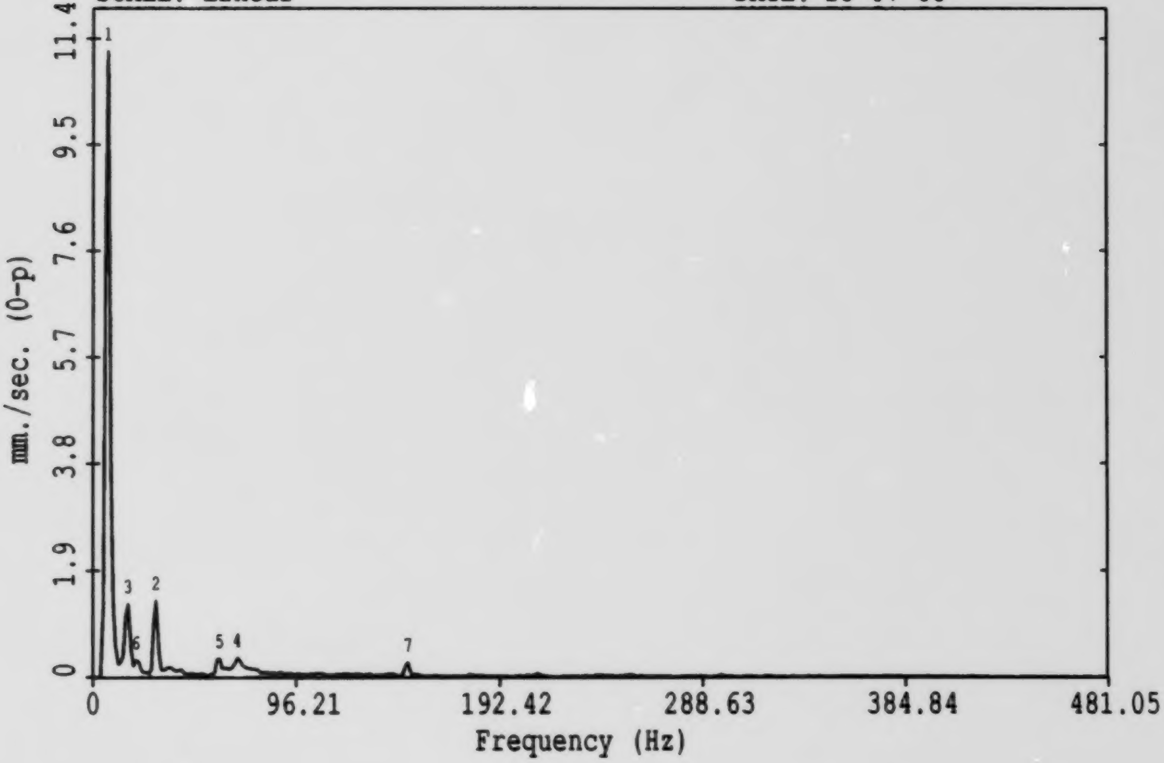


FIGURE 87

PNGS Unit 2 - ECIS Test #2 Moderator Pumpset Vibration

SIGNAL : Pumpset #5 - Motor Casing Vel E-W
PROCESS CONDITION : Dump Test

PEAK NO.	FREQUENCY	AMPLITUDE
1	7.2	10.31
2	30.1	3.85
3	19.2	1.14
4	60.1	0.45
5	89.0	0.43
6	63.7	0.43
7	149.1	0.39
8	44.5	0.35
9	289.8	0.32
10	46.9	0.29

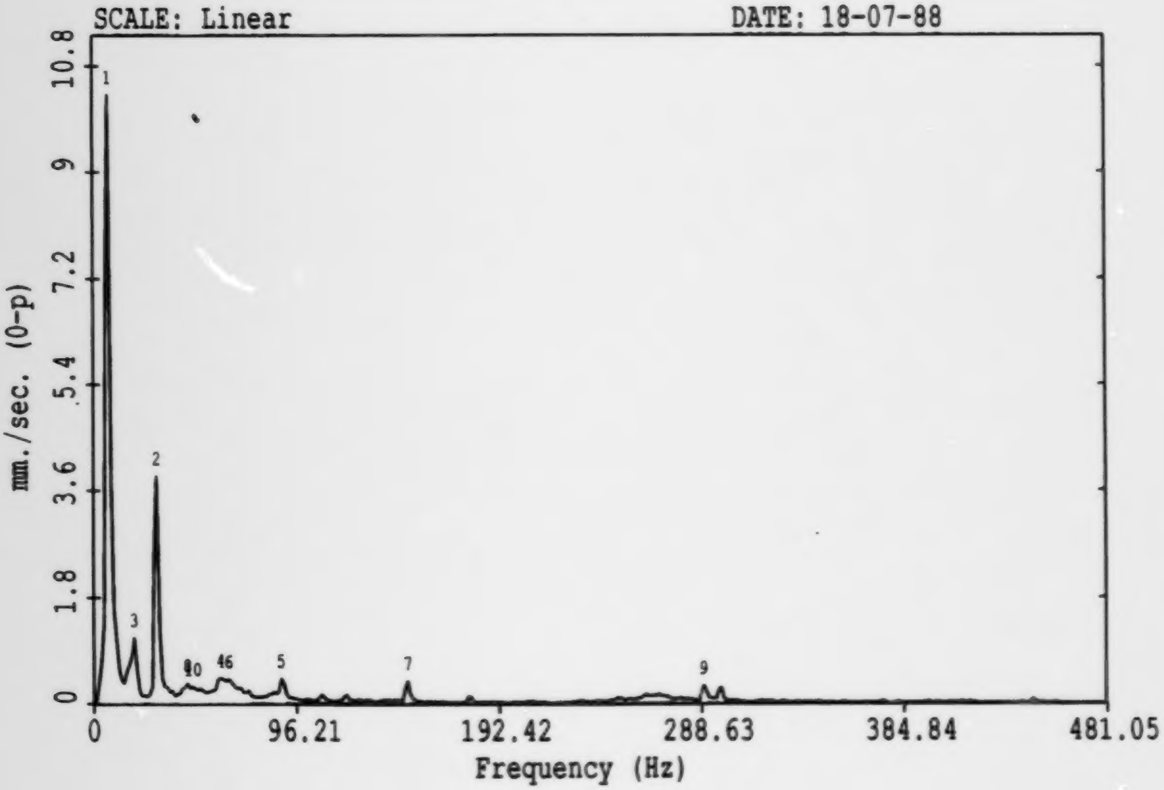


FIGURE 88

PNGS Unit 2 - ECIS Test #2 Moderator Pumpset Vibration

SIGNAL : Pumpset #5 - Motor Casing Vel N-S
PROCESS CONDITION : Dump Test

PEAK NO.	FREQUENCY	AMPLITUDE
1	7.2	4.43
2	9.6	2.59
3	30.1	0.93
4	58.9	0.73
5	16.8	0.66
6	19.2	0.59
7	44.5	0.44
8	149.1	0.28
9	298.3	0.28
10	89.0	0.24

SCALE: Linear DATE: 18-07-88

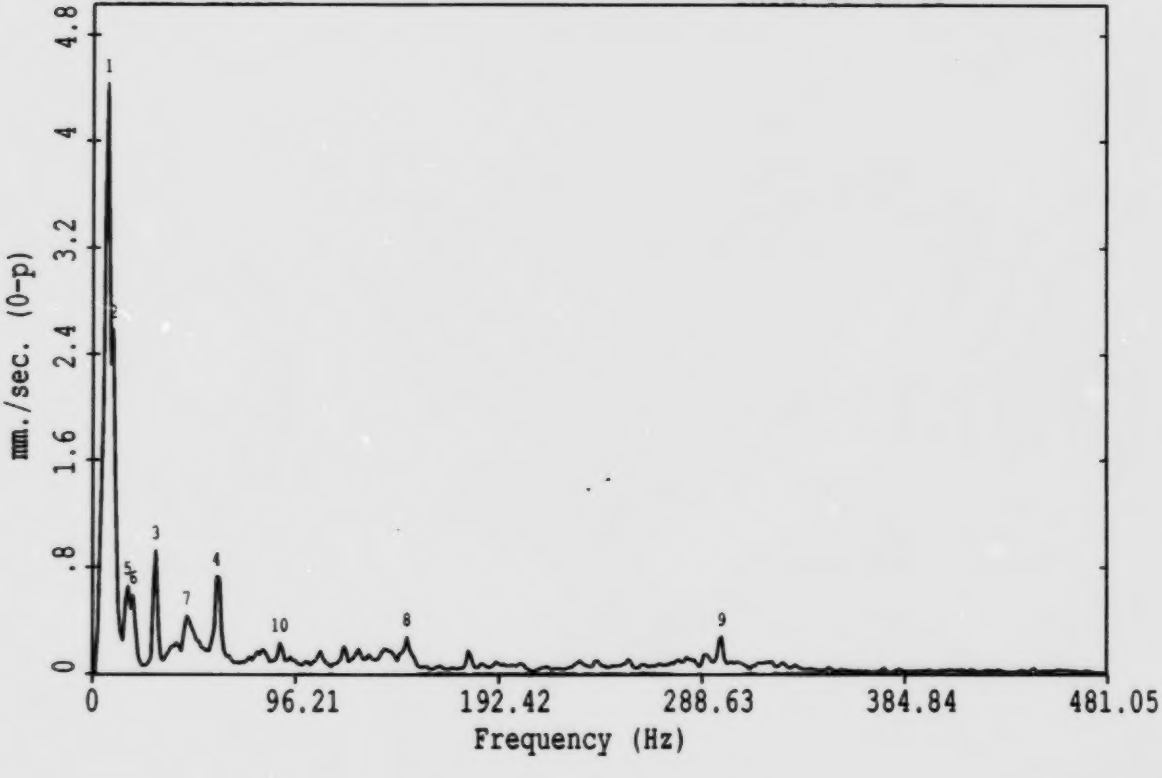


FIGURE 89

PNGS Unit 2 - ECIS Test #2 Moderator Pumpset Vibration

SIGNAL : Pumpset #1 - Pump Shaft Displacement E-W
PROCESS CONDITION : Dump Test

PEAK NO.	FREQUENCY	AMPLITUDE
1	30.1	72.31
2	58.9	23.67
3	149.1	22.17
4	89.0	7.78
5	2.4	7.52
6	119.1	4.78
7	178.0	3.51
8	208.1	3.09
9	267.0	2.97
10	109.4	2.85

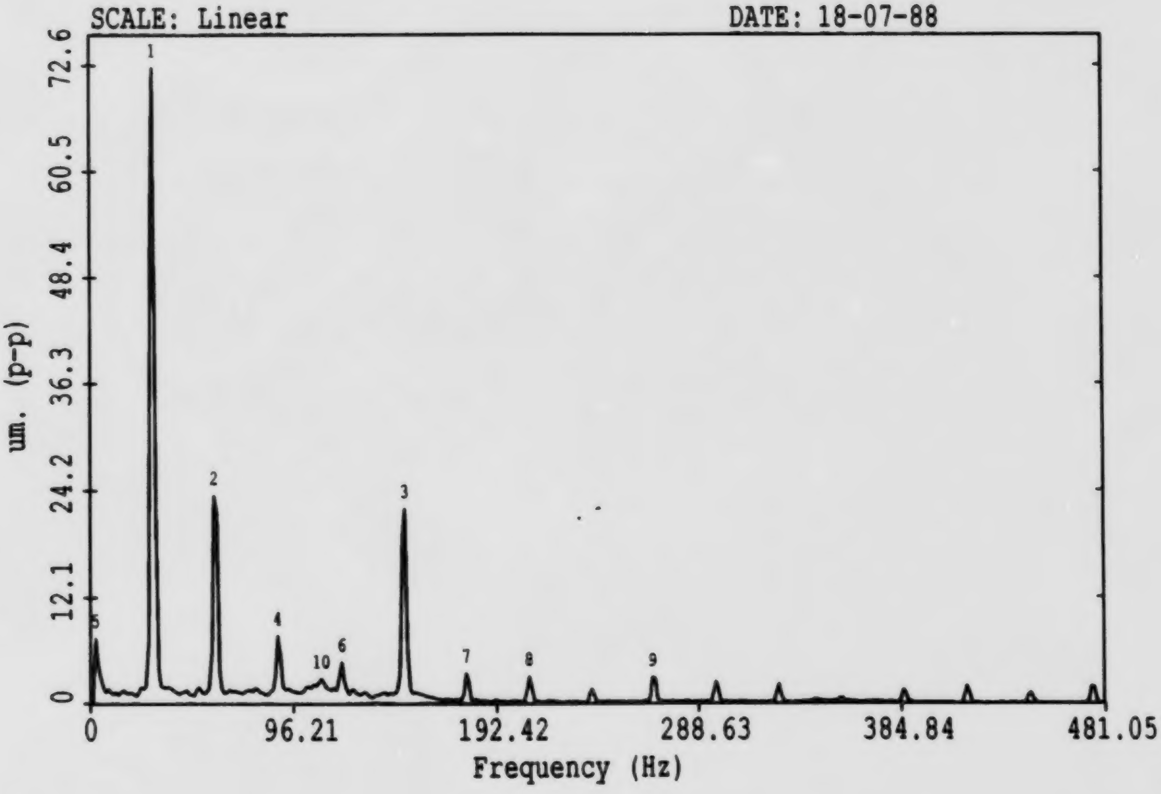


FIGURE 90

PNGS Unit 2 - ECIS Test #2 Moderator Pumpset Vibration

SIGNAL : Pumpset #1 - Pump Shaft Displacement N-S
PROCESS CONDITION : Dump Test

PEAK NO.	FREQUENCY	AMPLITUDE
1	30.1	81.51
2	149.1	17.29
3	58.9	15.86
4	89.0	9.23
5	6.0	7.14
6	119.1	4.37
7	2.4	3.42
8	416.1	3.10
9	33.7	2.94
10	74.6	2.81

SCALE: Linear DATE: 18-07-88

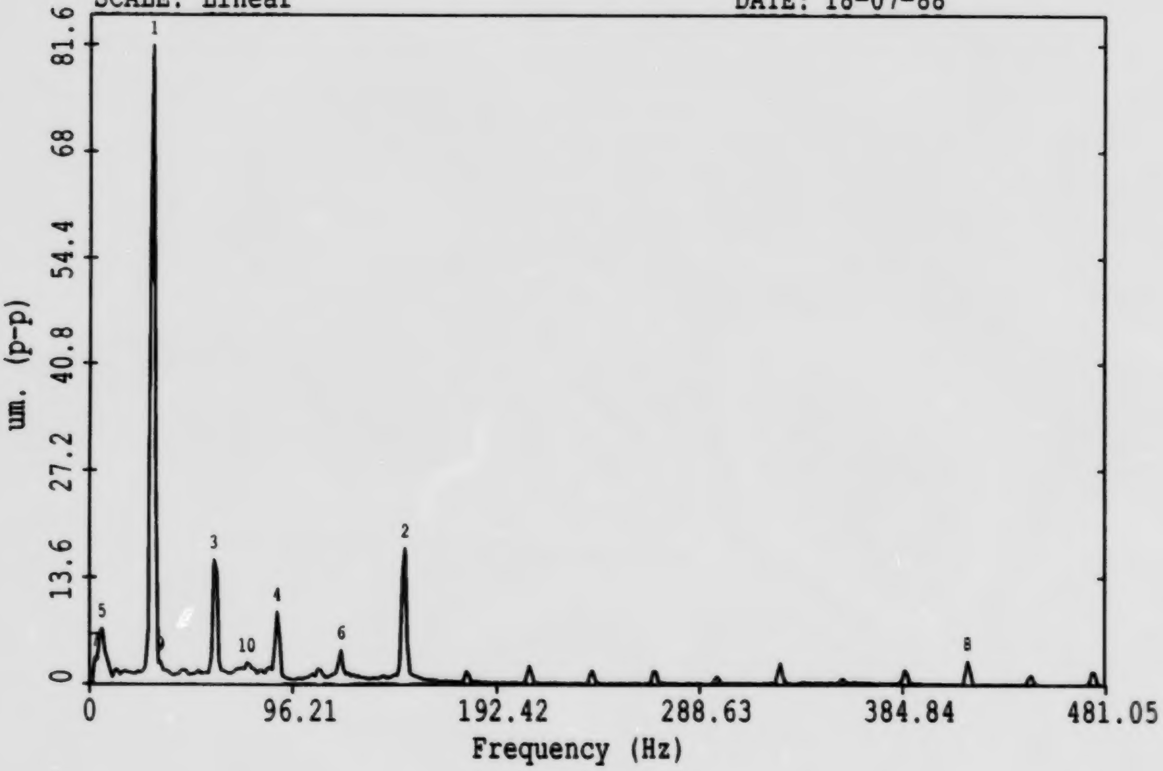


FIGURE 91

PNGS Unit 2 - ECIS Test #2 Moderator Pumpset Vibration

SIGNAL : Pumpset #2 - Pump Shaft Displacement E-W
PROCESS CONDITION : Dump Test

PEAK NO.	FREQUENCY	AMPLITUDE
1	30.1	162.40
2	58.9	25.58
3	89.0	11.90
4	178.0	11.20
5	149.1	9.73
6	2.4	5.55
7	119.1	5.10

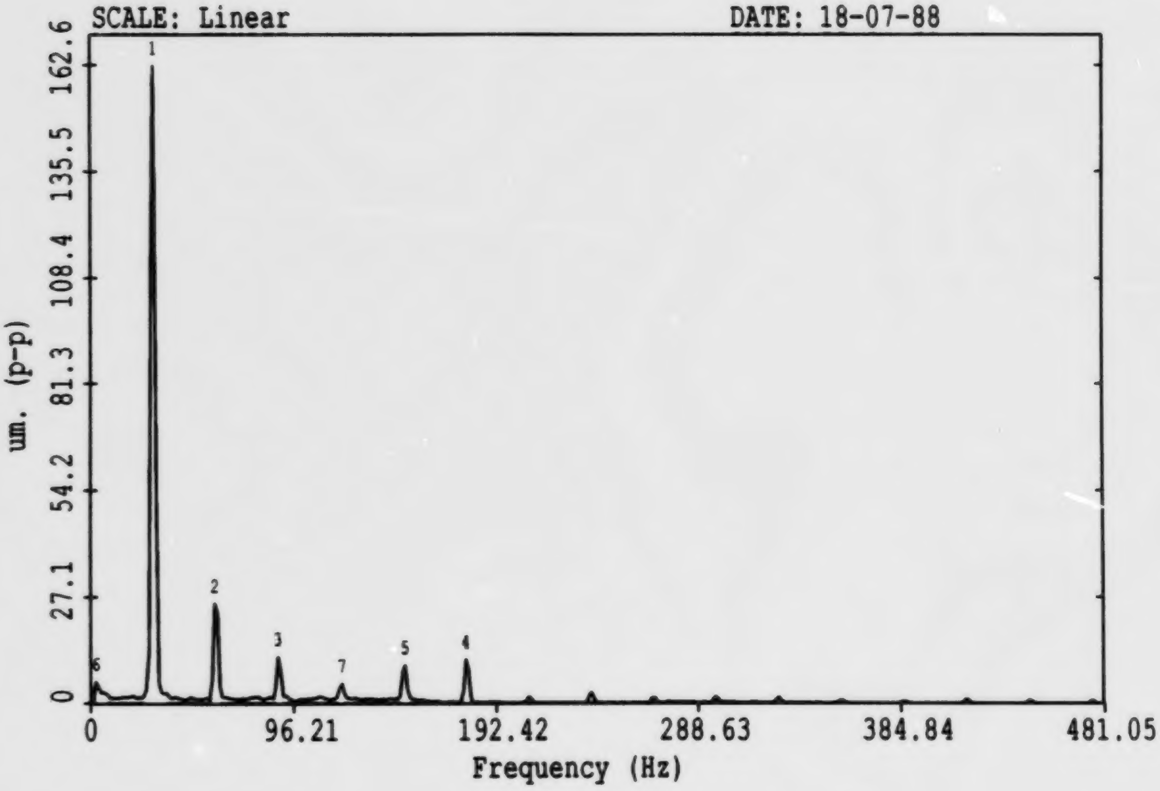


FIGURE 92

PNGS Unit 2 - ECIS Test #2 Moderator Pumpset Vibration

SIGNAL : Pumpset #2 - Pump Shaft Displacement N-S
PROCESS CONDITION : Dump Test

PEAK NO.	FREQUENCY	AMPLITUDE
1	30.1	189.20
2	60.1	44.77
3	2.4	8.43
4	89.0	7.00
5	6.0	4.45

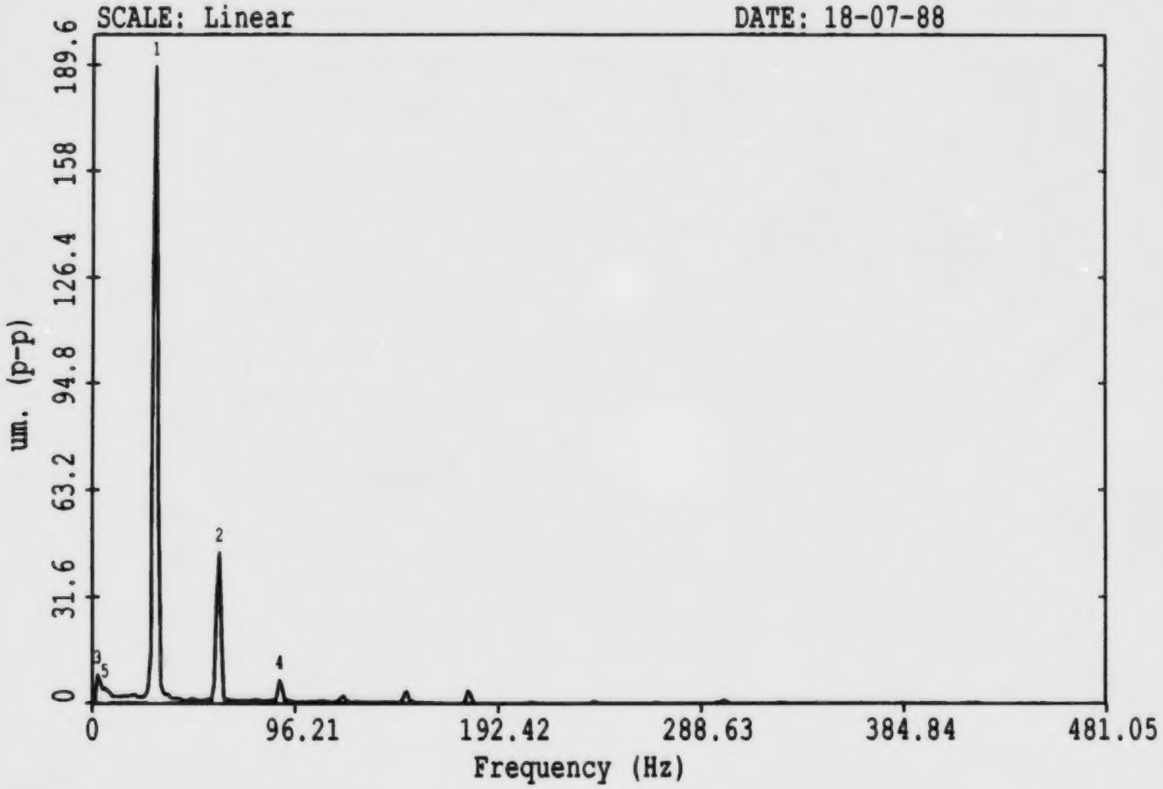


FIGURE 93

PNGS Unit 2 - ECIS Test #2 Moderator Pumpset Vibration

SIGNAL : Pumpset #3 - Pump Shaft Displacement E-W
PROCESS CONDITION : Dump Test

PEAK NO.	FREQUENCY	AMPLITUDE
1	30.1	165.20
2	149.1	14.99
3	58.9	10.51
4	89.0	8.24
5	7.2	4.61

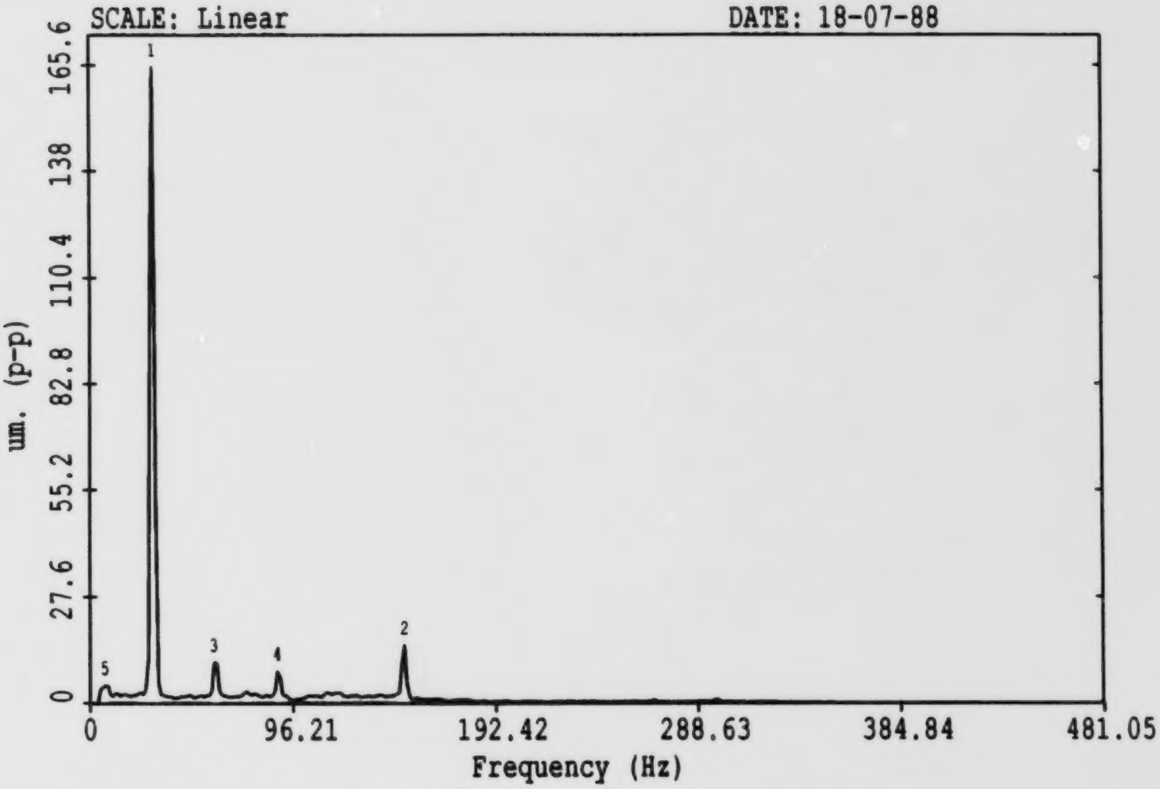


FIGURE 94

PNGS Unit 2 - ECIS Test #2 Moderator Pumpset Vibration

SIGNAL : Pumpset #4 - Pump Shaft Displacement E-W
PROCESS CONDITION : Dump Test

PEAK NO.	FREQUENCY	AMPLITUDE
1	7.2	9.80
2	16.8	2.34
3	68.6	1.52
4	30.1	1.05
5	74.6	0.85
6	58.9	0.79
7	62.5	0.63
8	149.1	0.61
9	86.6	0.59
10	83.0	0.58

SCALE: Linear DATE: 18-07-88

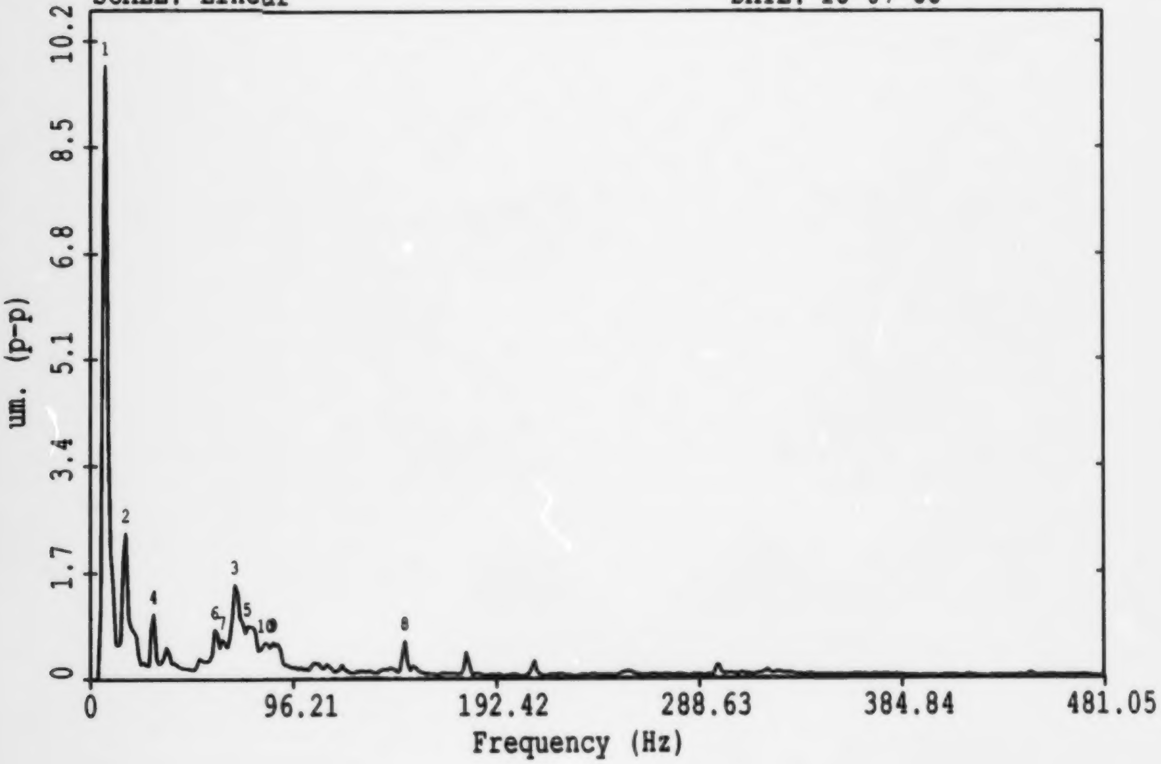


FIGURE 95

PNGS Unit 2 - ECIS Test #2 Moderator Pumpset Vibration

SIGNAL : Pumpset #5 - Pump Shaft Displacement E-W
PROCESS CONDITION : Dump Test

PEAK NO.	FREQUENCY	AMPLITUDE
1	30.1	131.30
2	149.1	14.68
3	2.4	10.03
4	7.2	8.94
5	60.1	6.15
6	119.1	3.43
7	108.2	3.23

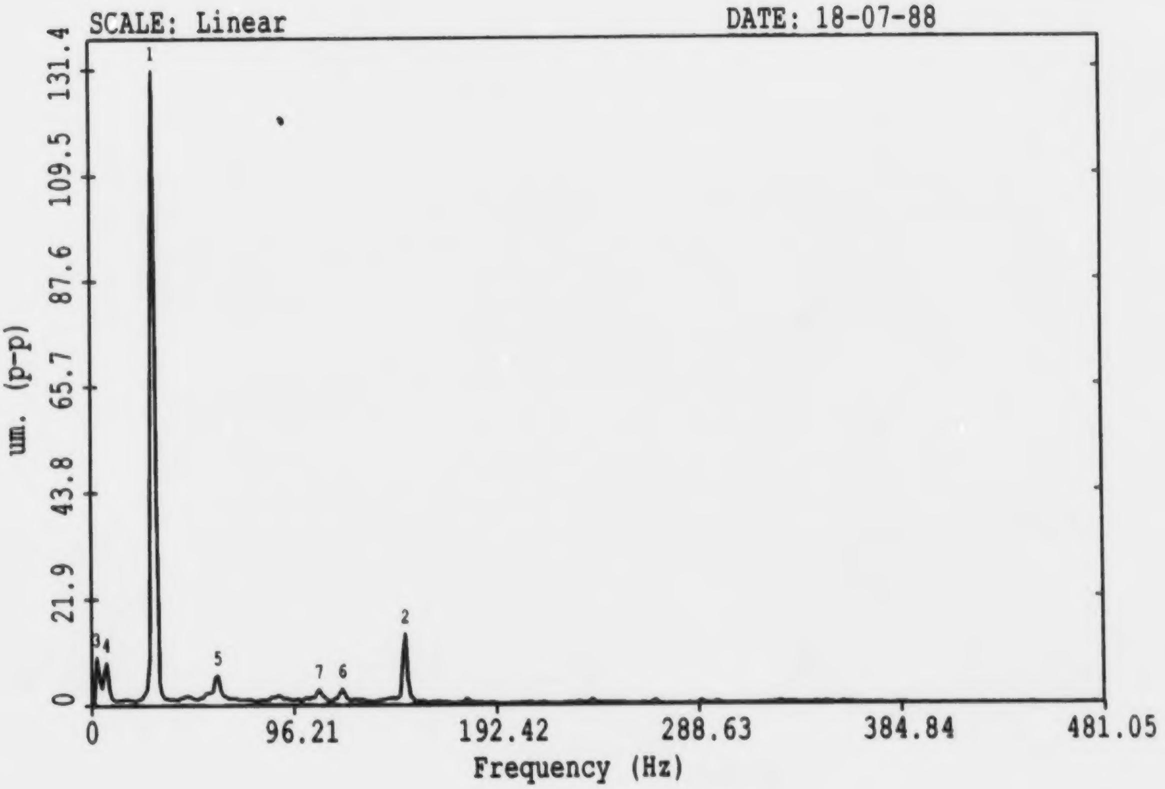


FIGURE 96

PNGS Unit 2 - ECIS Test #2 Moderator Pumpset Vibration

SIGNAL : Pumpset #5 - Pump Shaft Displacement N-S
PROCESS CONDITION : Dump Test

PEAK NO.	FREQUENCY	AMPLITUDE
1	30.1	137.90
2	7.2	11.81
3	149.1	9.50
4	60.1	8.15
5	2.4	5.93
6	89.0	5.47
7	119.1	3.99

SCALE: Linear DATE: 18-07-88

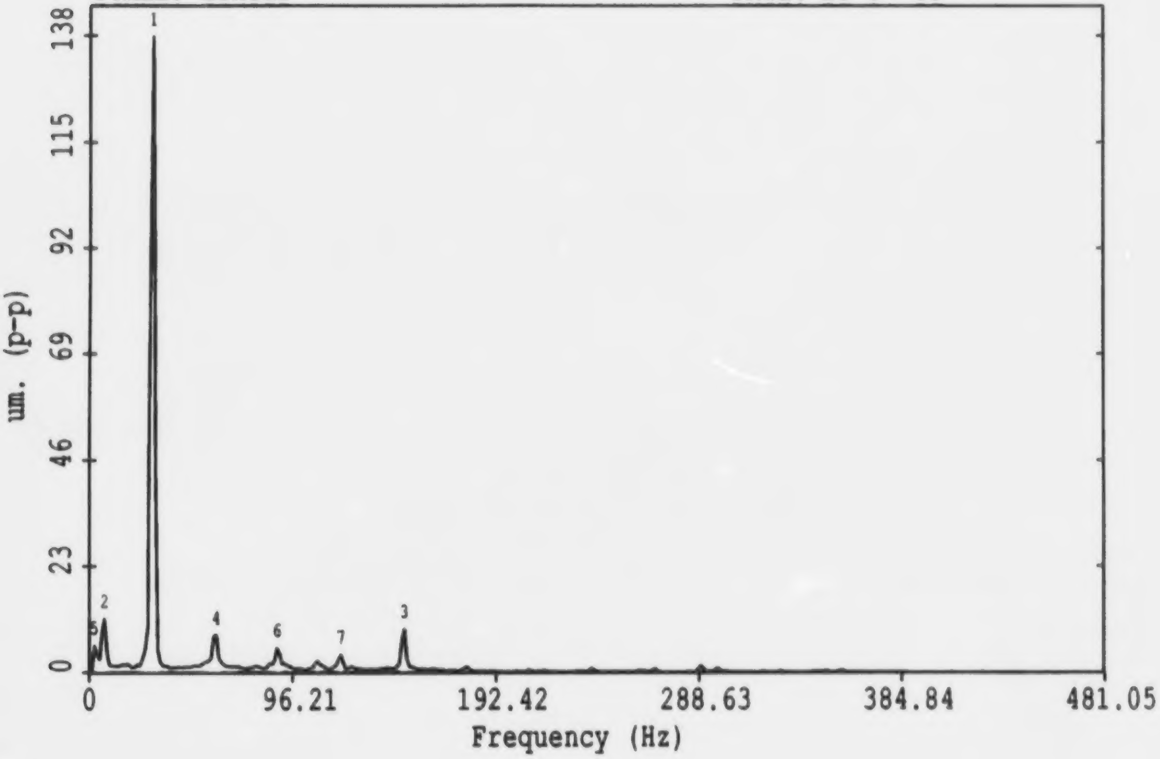


FIGURE 97

PNGS Unit 2 - ECIS Test #2 Moderator Pumpset Vibration

SIGNAL : Expansion Joint #3 Vertical Velocity
PROCESS CONDITION : Dump Test

PEAK NO.	FREQUENCY	AMPLITUDE
1	8.4	3.11
2	149.1	2.41
3	16.8	1.35
4	119.1	1.31
5	13.2	1.17
6	19.2	1.11
7	30.1	0.97
8	178.0	0.76
9	60.1	0.75
10	122.7	0.67

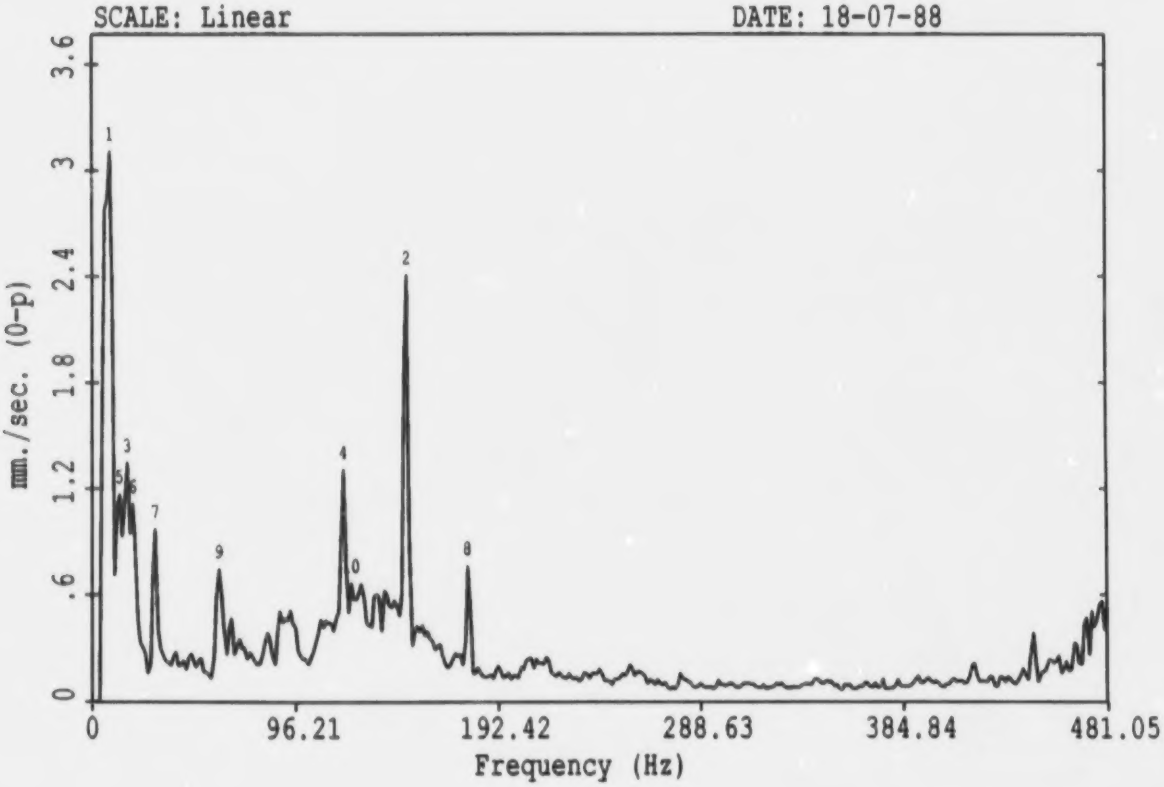


FIGURE 98

PNGS Unit 2 - ECIS Test #2 Moderator Pumpset Vibration

SIGNAL : Expansion Joint #3 Horizontal Velocity
PROCESS CONDITION : Dump Test

PEAK NO.	FREQUENCY	AMPLITUDE
1	149.1	2.62
2	30.1	1.93
3	119.1	1.87
4	8.4	1.42
5	60.1	1.27
6	178.0	1.25
7	210.5	1.00
8	6.0	0.84
9	14.4	0.80
10	123.9	0.80

SCALE: Linear DATE: 18-07-88

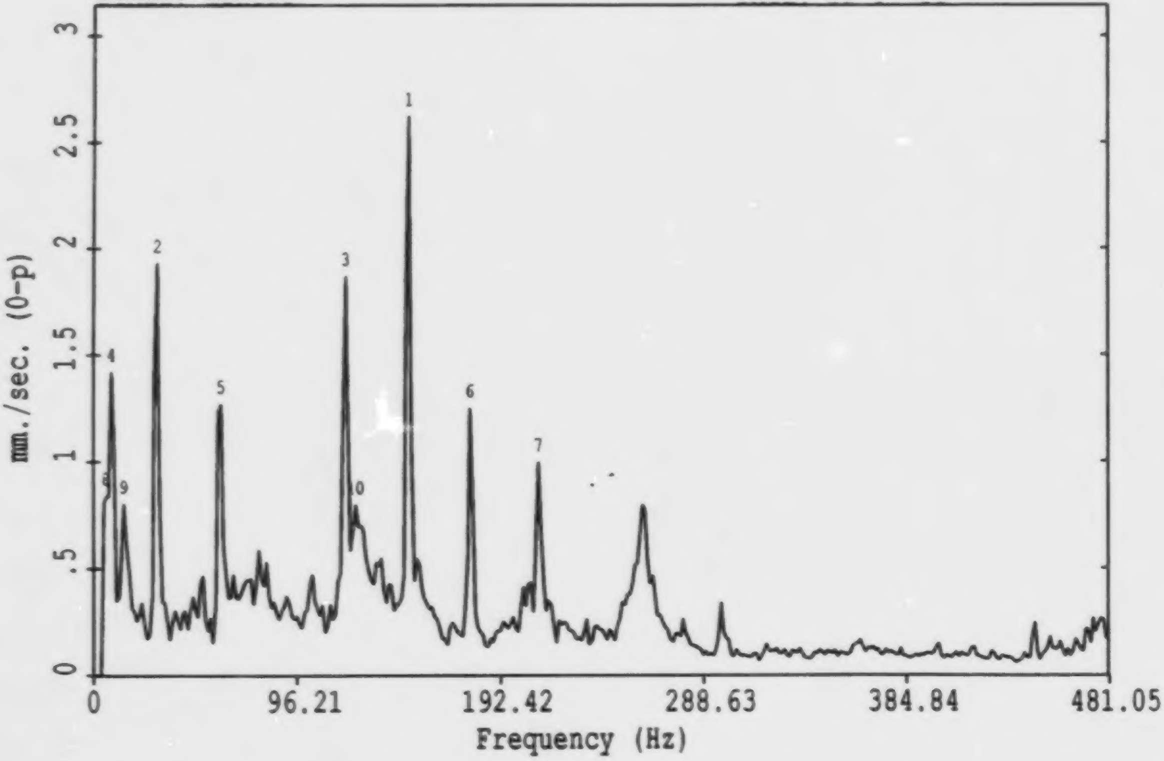


FIGURE 99

PNGS Unit 2 - ECIS Test #2 Moderator Pumpset Vibration

SIGNAL : Expansion Joint #3 Axial Velocity
PROCESS CONDITION : Dump Test

PEAK NO.	FREQUENCY	AMPLITUDE
1	149.1	4.10
2	16.8	1.87
3	259.8	1.78
4	8.4	1.53
5	119.1	1.37
6	60.1	1.25
7	6.0	1.24
8	30.1	1.20
9	210.5	0.88
10	178.0	0.82

SCALE: Linear DATE: 18-07-88

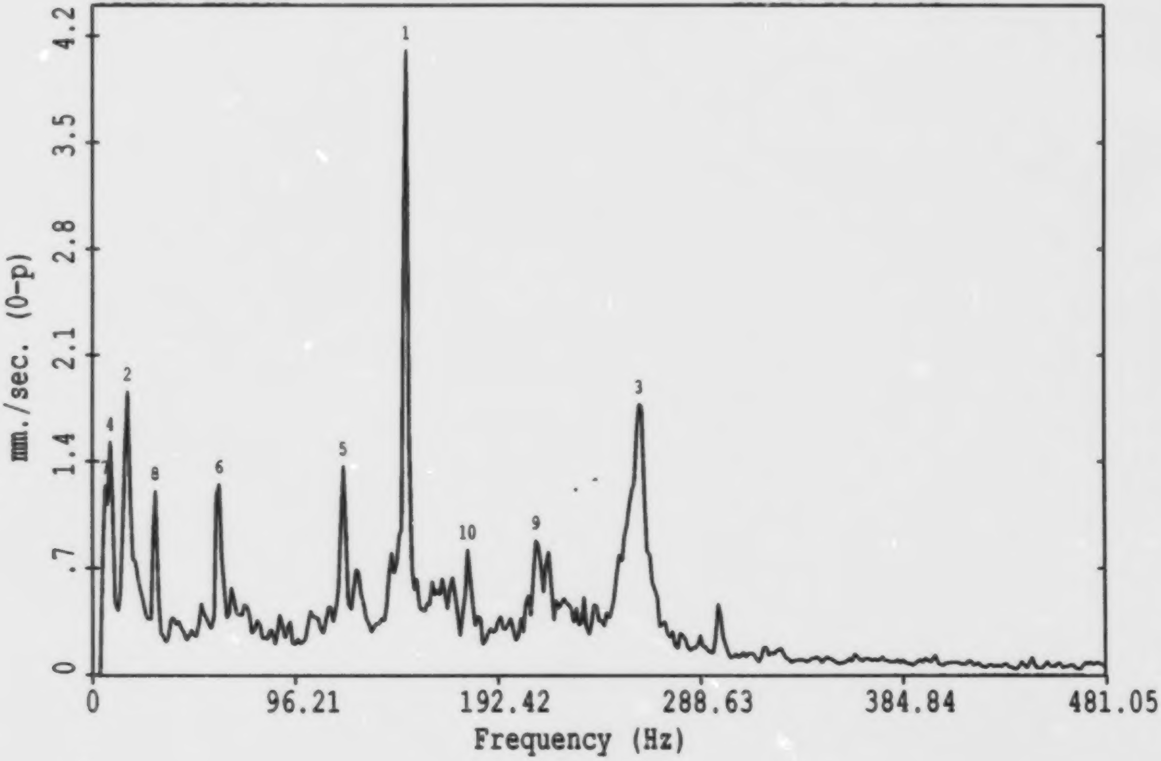


FIGURE 100

PNGS Unit 2 - ECIS Test #2 Moderator Pumpset Vibration

SIGNAL : Expansion Joint #4 Horizontal Velocity
PROCESS CONDITION : Dump Test

PEAK NO.	FREQUENCY	AMPLITUDE
1	7.2	3.75
2	19.2	2.14
3	60.1	0.97
4	30.1	0.83
5	149.1	0.69
6	119.1	0.53
7	178.0	0.51
8	297.1	0.51
9	46.9	0.42
10	68.6	0.40

SCALE: Linear DATE: 18-07-88

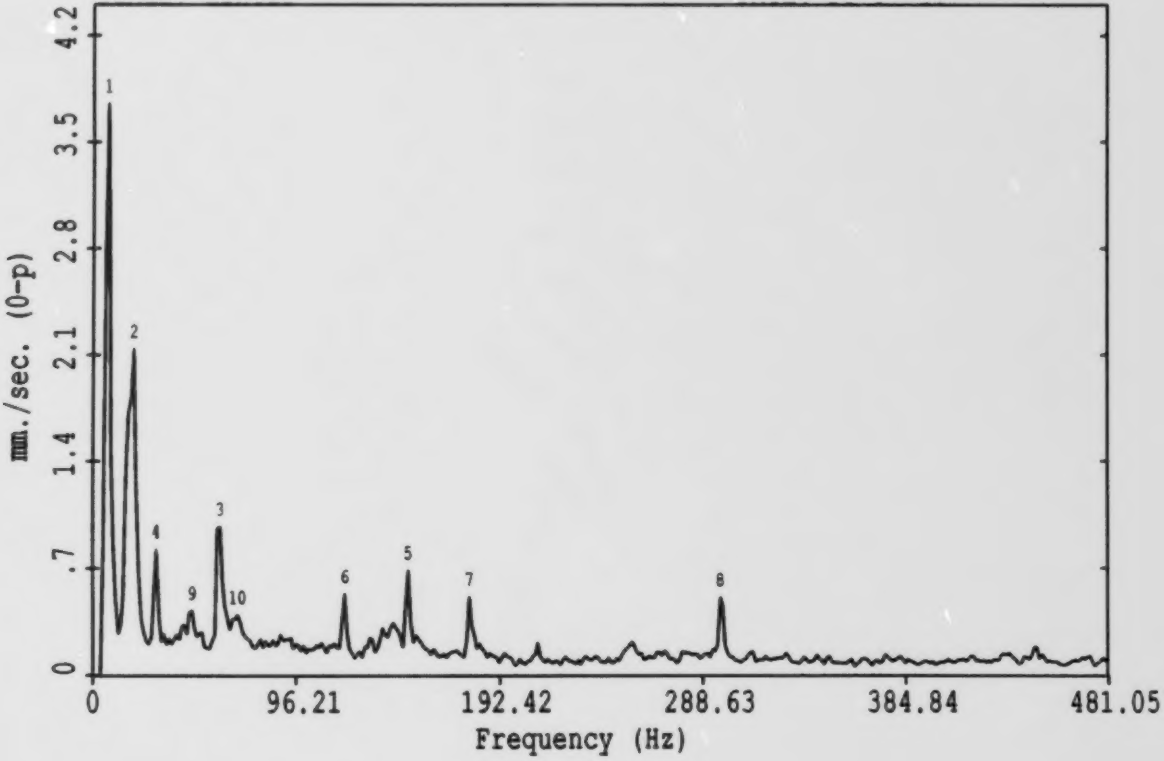


FIGURE 101

PNGS Unit 2 - ECIS Test #2 Moderator Pumpset Vibration

SIGNAL : Expansion Joint #4 Axial Velocity
PROCESS CONDITION : Dump Test

PEAK NO.	FREQUENCY	AMPLITUDE
1	30.1	2.51
2	149.1	1.58
3	7.2	1.26
4	68.6	1.20
5	4.8	0.96
6	210.5	0.86
7	66.1	0.82
8	15.6	0.79
9	60.1	0.74
10	38.5	0.72

SCALE: Linear

DATE: 18-07-88

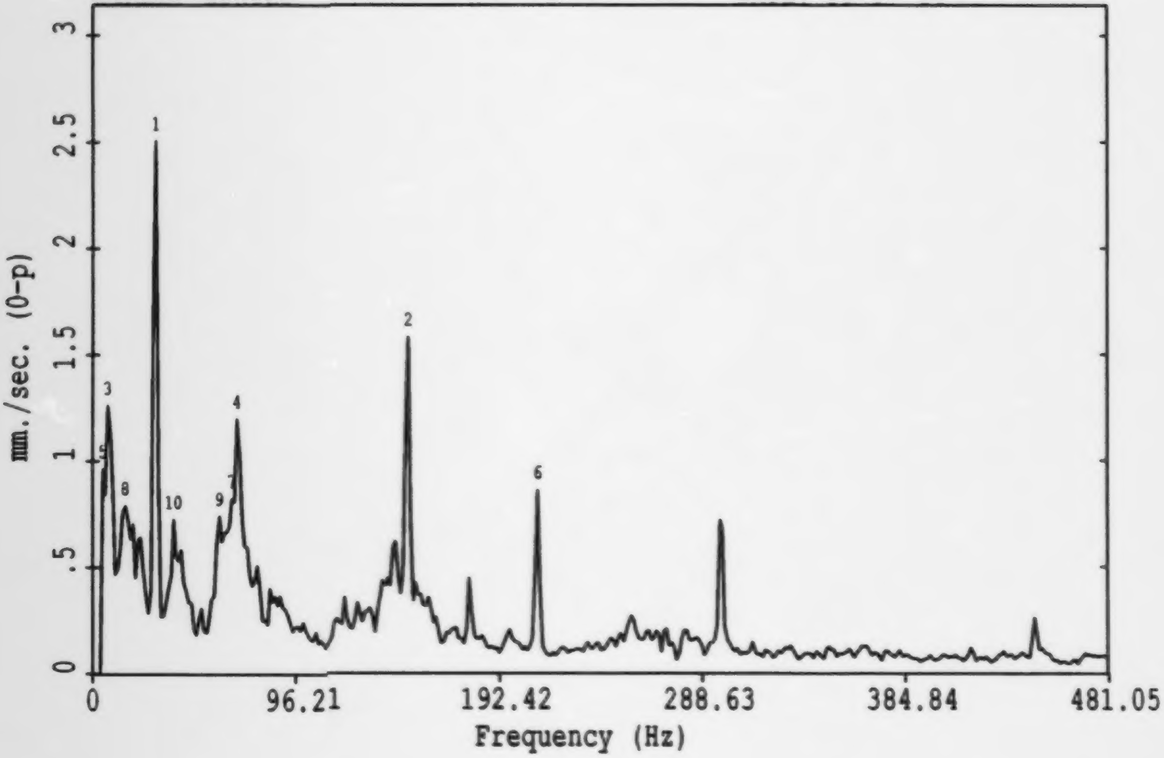


FIGURE 102

PNGS Unit 2 - ECIS Test #2 Moderator Pumpset Vibration

SIGNAL : Pumpset #1 - Motor Casing Vel E-W
PROCESS CONDITION : CIV Closure Test

PEAK NO.	FREQUENCY	AMPLITUDE
1	6.0	19.36
2	30.1	2.72
3	20.4	1.88
4	25.3	1.79
5	149.1	0.89
6	44.5	0.81
7	79.4	0.81
8	38.5	0.77
9	40.9	0.66
10	73.4	0.65

SCALE: Linear DATE: 18-07-88

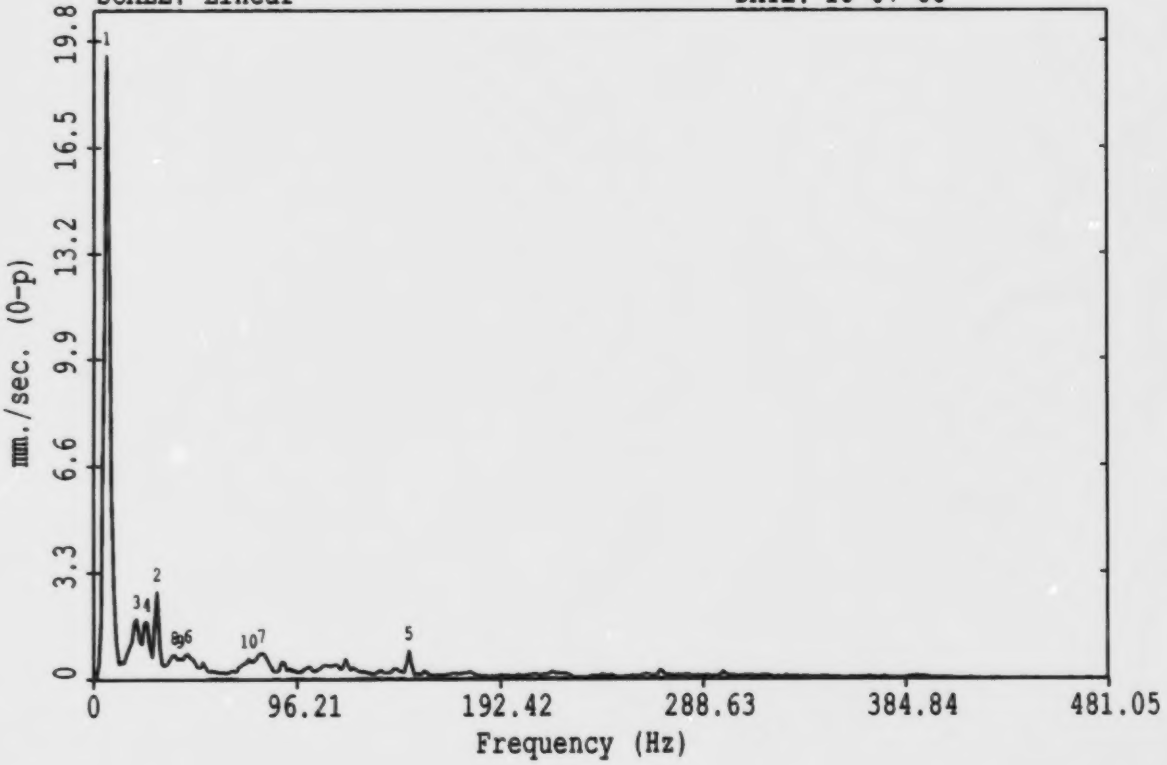


FIGURE 103

PNGS Unit 2 - ECIS Test #2 Moderator Pumpset Vibration

SIGNAL : Pumpset #1 - Motor Casing Vel N-S
PROCESS CONDITION : CIV Closure Test

PEAK NO.	FREQUENCY	AMPLITUDE
1	6.0	12.24
2	13.2	2.53
3	30.1	2.09
4	67.3	1.49
5	21.6	1.44
6	73.4	1.37
7	77.0	1.25
8	71.0	1.24
9	42.1	0.98
10	58.9	0.85

SCALE: Linear

DATE: 18-07-88

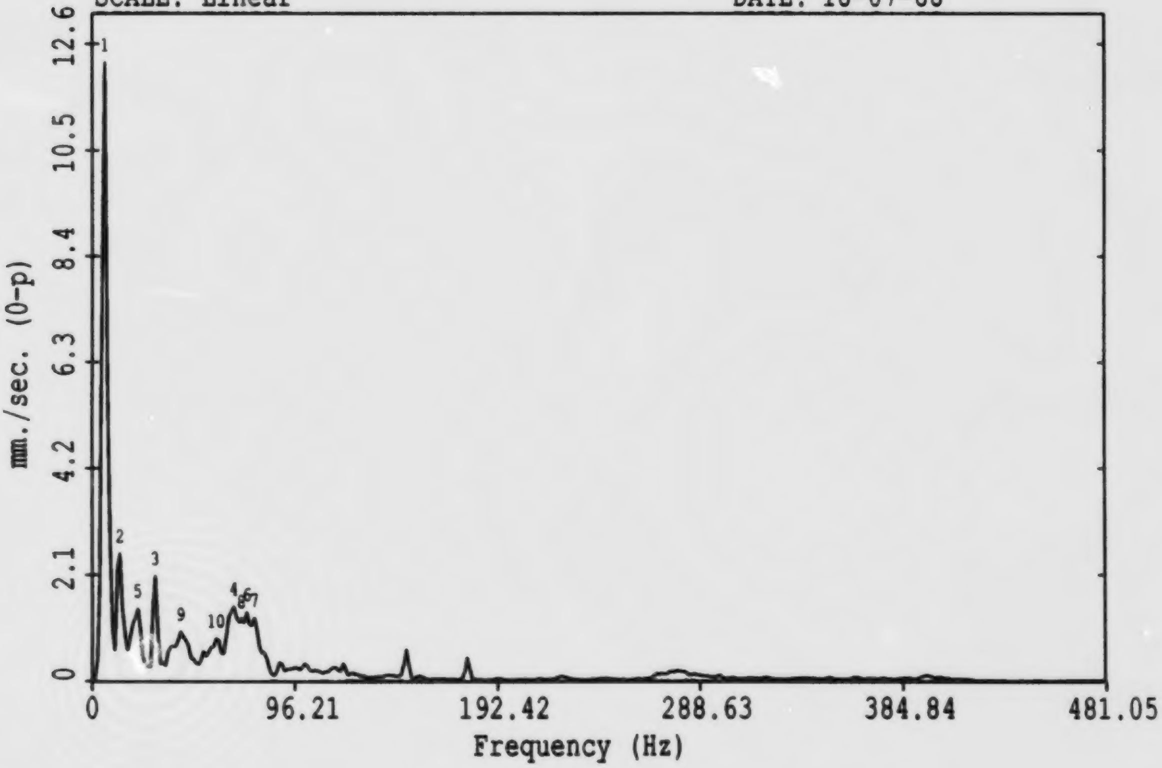


FIGURE 104

PNGS Unit 2 - ECIS Test #2 Moderator Pumpset Vibration

SIGNAL : Pumpset #2 - Motor Casing Vel E-W
PROCESS CONDITION : CIV Closure Test

PEAK NO.	FREQUENCY	AMPLITUDE
1	6.0	12.04
2	9.6	4.38
3	13.2	3.73
4	30.1	1.93
5	149.1	1.55
6	43.3	1.21
7	38.5	1.16
8	22.9	0.94
9	73.4	0.88
10	95.0	0.72

SCALE: Linear

DATE: 18-07-88

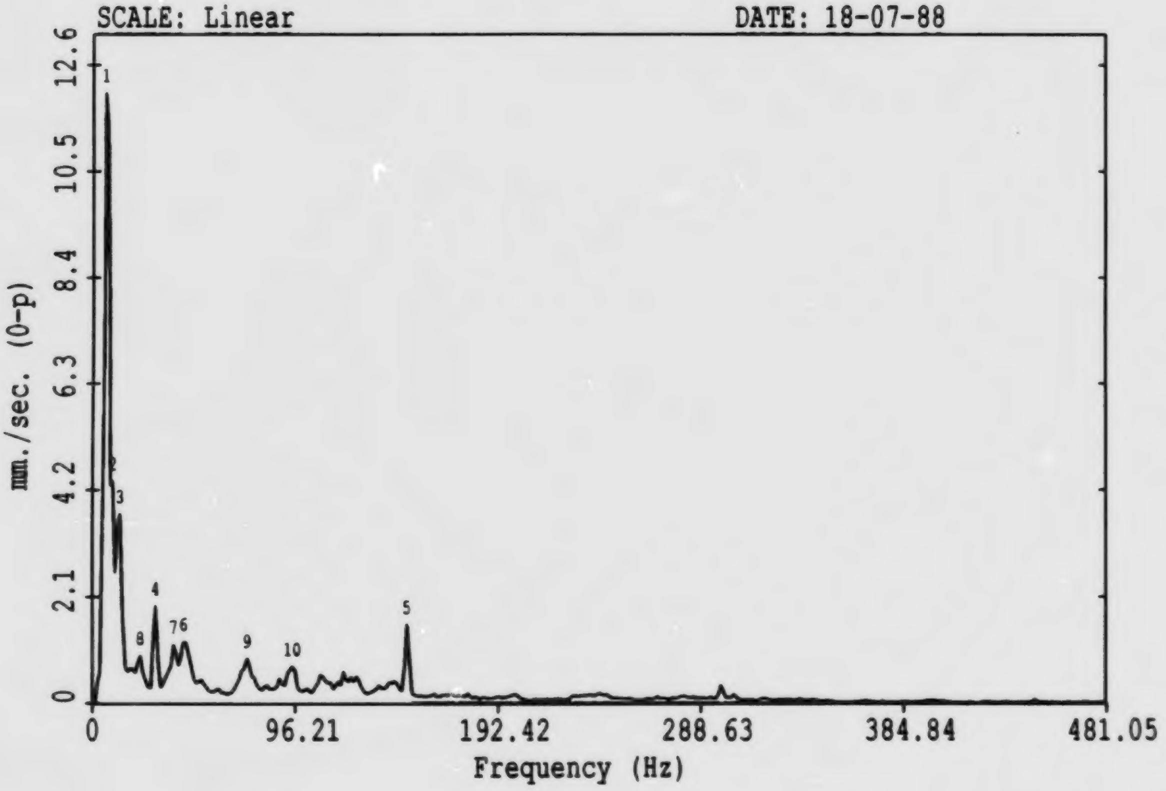


FIGURE 105

PNGS Unit 2 - ECIS Test #2 Moderator Pumpset Vibration

SIGNAL : Pumpset #2 - Motor Casing Vel N-S
PROCESS CONDITION : CIV Closure Test

PEAK NO.	FREQUENCY	AMPLITUDE
1	6.0	30.88
2	30.1	2.71
3	13.2	2.24
4	149.1	1.16
5	42.1	1.10
6	19.2	1.08
7	78.2	1.05
8	60.1	1.01
9	72.2	1.00
10	69.8	0.98

SCALE: Linear

DATE: 18-07-88

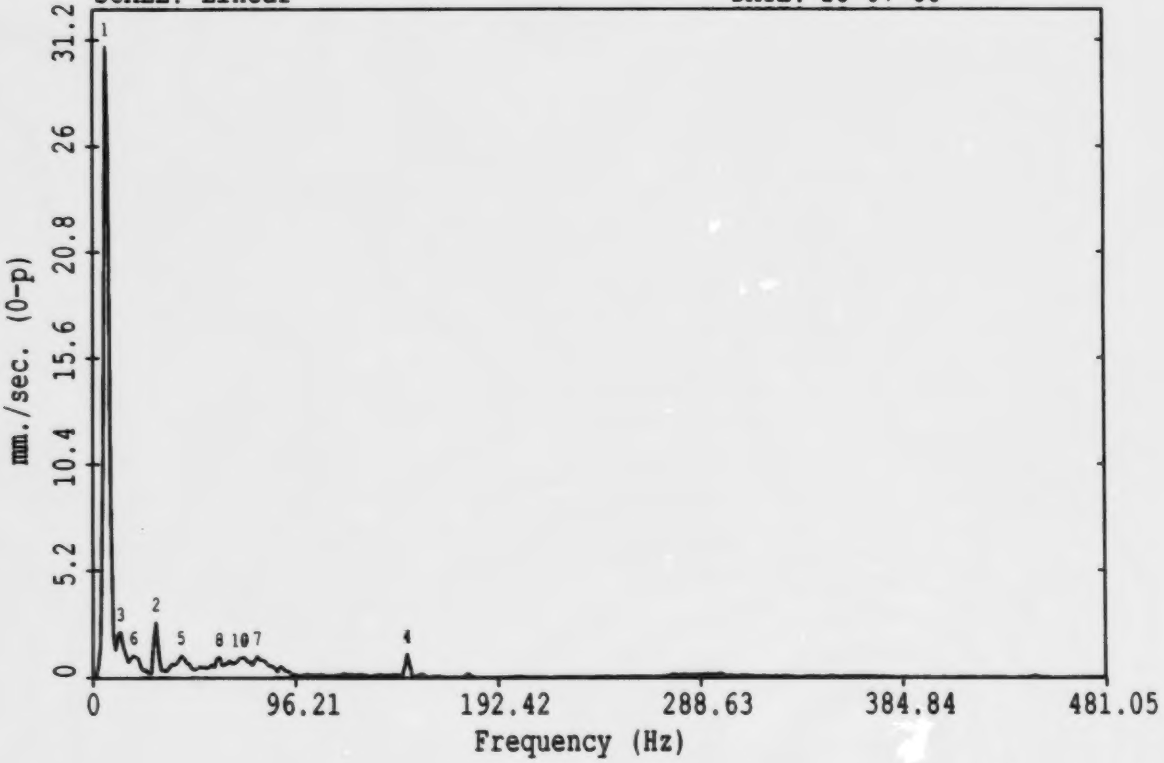


FIGURE 106

PNGS Unit 2 - ECIS Test #2 Moderator Pumpset Vibration

SIGNAL : Pumpset #3 - Motor Casing Velocity E-W
PROCESS CONDITION : CIV Closure Test

PEAK NO.	FREQUENCY	AMPLITUDE
1	6.0	8.04
2	149.1	4.59
3	30.1	1.91
4	9.6	1.57
5	16.8	1.52
6	13.2	1.17
7	25.3	0.85
8	21.6	0.73
9	37.3	0.68
10	34.9	0.65

SCALE: Linear DATE: 18-07-88

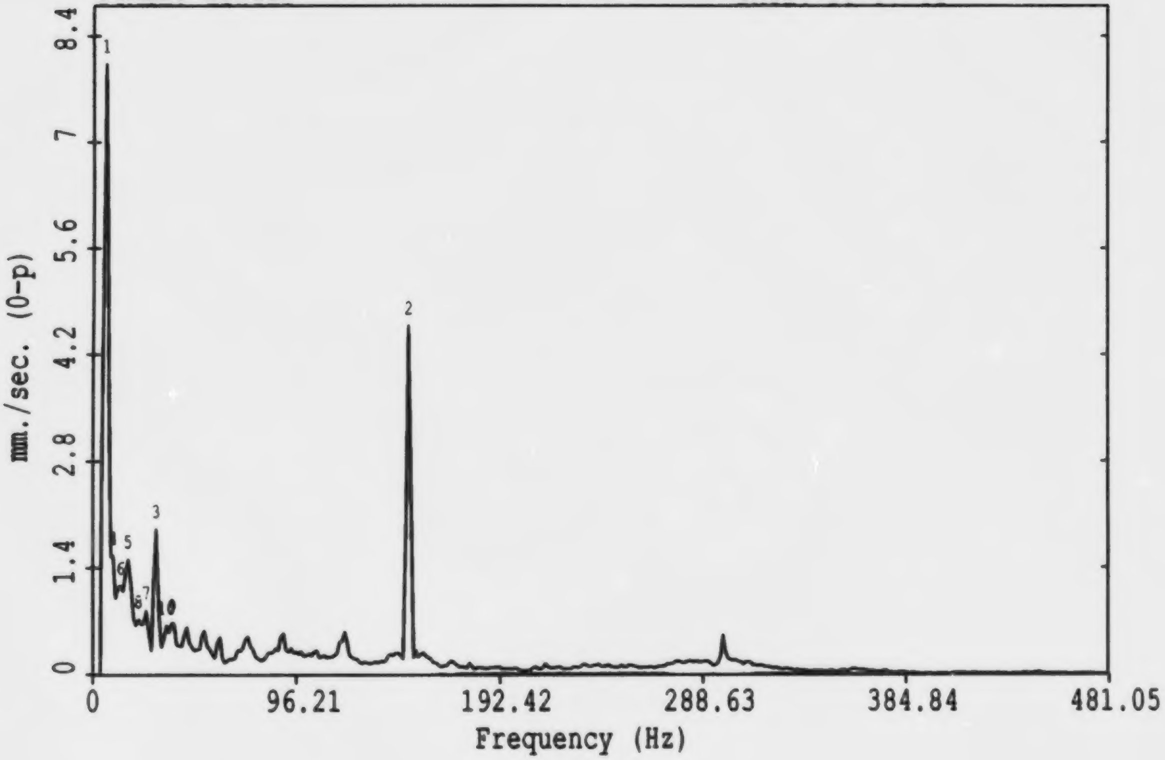


FIGURE 107

PNGS Unit 2 - ECIS Test #2 Moderator Pumpset Vibration

SIGNAL : Pumpset #3 - Motor Casing Velocity N-S
PROCESS CONDITION : CIV Closure Test

PEAK NO.	FREQUENCY	AMPLITUDE
1	6.0	16.76
2	30.1	1.68
3	81.8	1.05
4	13.2	1.02
5	149.1	0.95
6	69.8	0.89
7	16.8	0.70
8	75.8	0.68
9	42.1	0.59
10	60.1	0.49

SCALE: Linear

DATE: 18-07-88

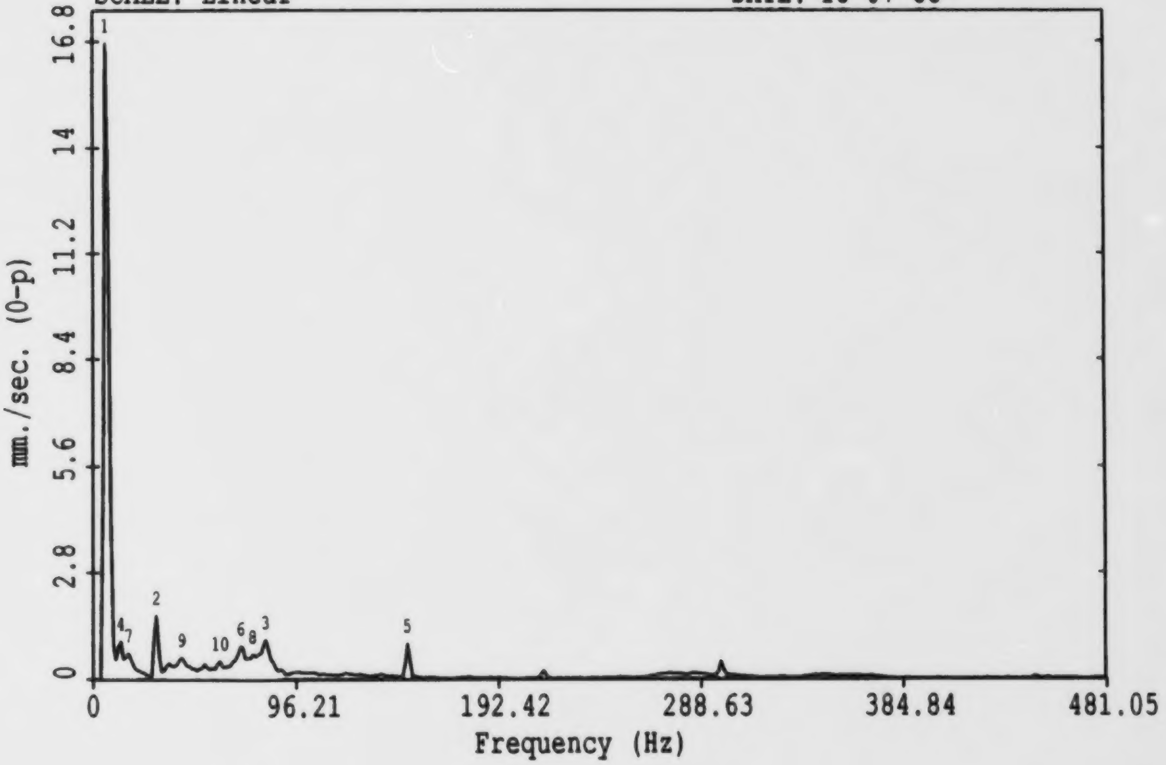


FIGURE 108

PNGS Unit 2 - ECIS Test #2 Moderator Pumpset Vibration

SIGNAL : Pumpset #4 - Motor Casing Velocity E-W
PROCESS CONDITION : CIV Closure Test

PEAK NO.	FREQUENCY	AMPLITUDE
1	7.2	4.15
2	16.8	1.53
3	30.1	1.02
4	21.6	0.70
5	68.6	0.70
6	60.1	0.49
7	66.1	0.47
8	36.1	0.44
9	40.9	0.41
10	33.7	0.34

SCALE: Linear

DATE: 18-07-88

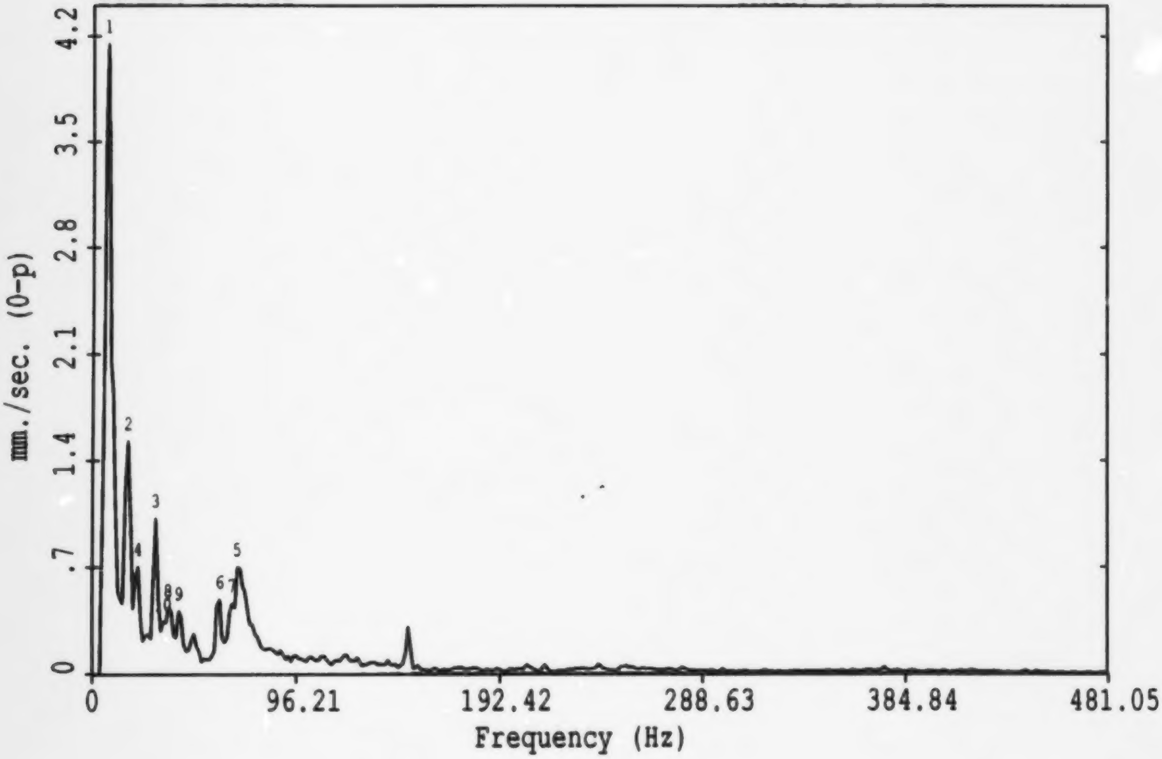


FIGURE 109

PNGS Unit 2 - ECIS Test #2 Moderator Pumpset Vibration

SIGNAL : Pumpset #5 - Motor Casing Vel E-W
PROCESS CONDITION : CIV Closure Test

PEAK NO.	FREQUENCY	AMPLITUDE
1	7.2	6.75
2	19.2	3.48
3	9.6	3.05
4	30.1	2.71
5	33.7	1.85
6	69.8	1.44
7	67.3	1.33
8	13.2	1.05
9	49.3	0.97
10	149.1	0.95

SCALE: Linear

DATE: 18-07-88

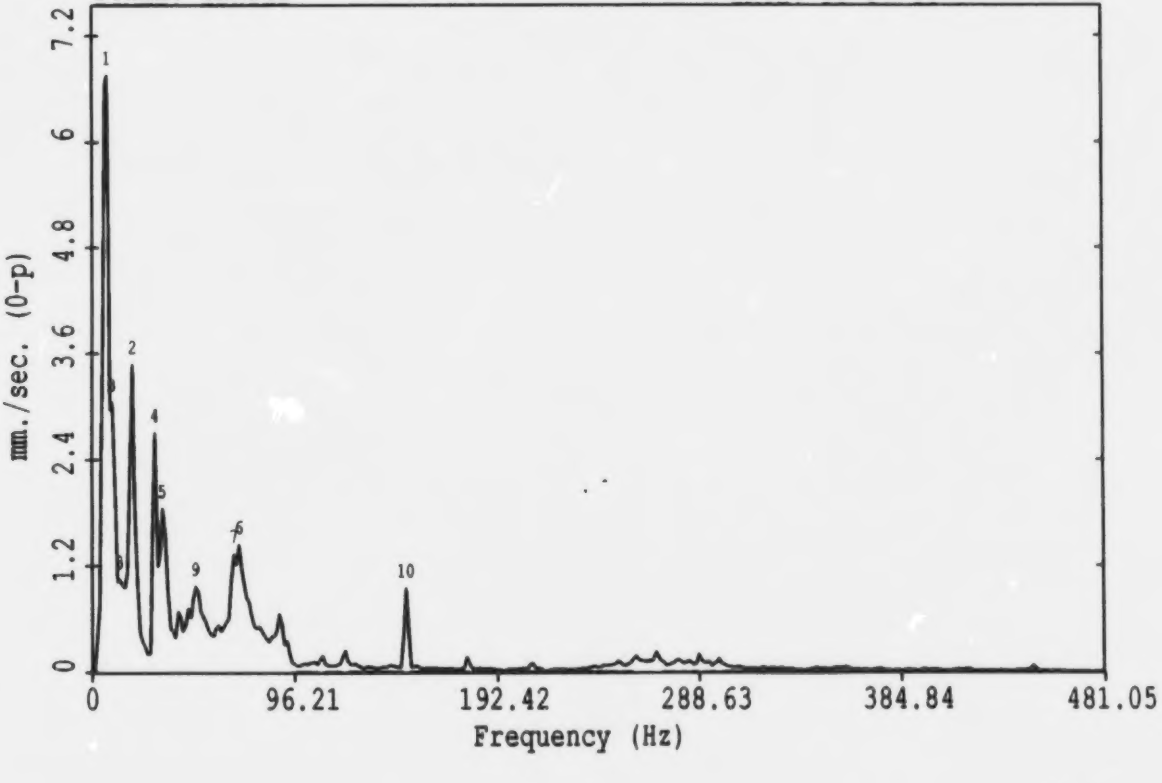


FIGURE 110

PNGS Unit 2 - ECIS Test #2 Moderator Pumpset Vibration

SIGNAL : Pumpset #5 - Motor Casing Vel N-S
PROCESS CONDITION : CIV Closure Test

PEAK NO.	FREQUENCY	AMPLITUDE
1	6.0	6.76
2	9.6	4.44
3	19.2	1.88
4	30.1	1.27
5	45.7	1.23
6	49.3	1.10
7	39.7	0.68
8	42.1	0.67
9	84.2	0.45
10	56.5	0.43

SCALE: Linear

DATE: 18-07-88

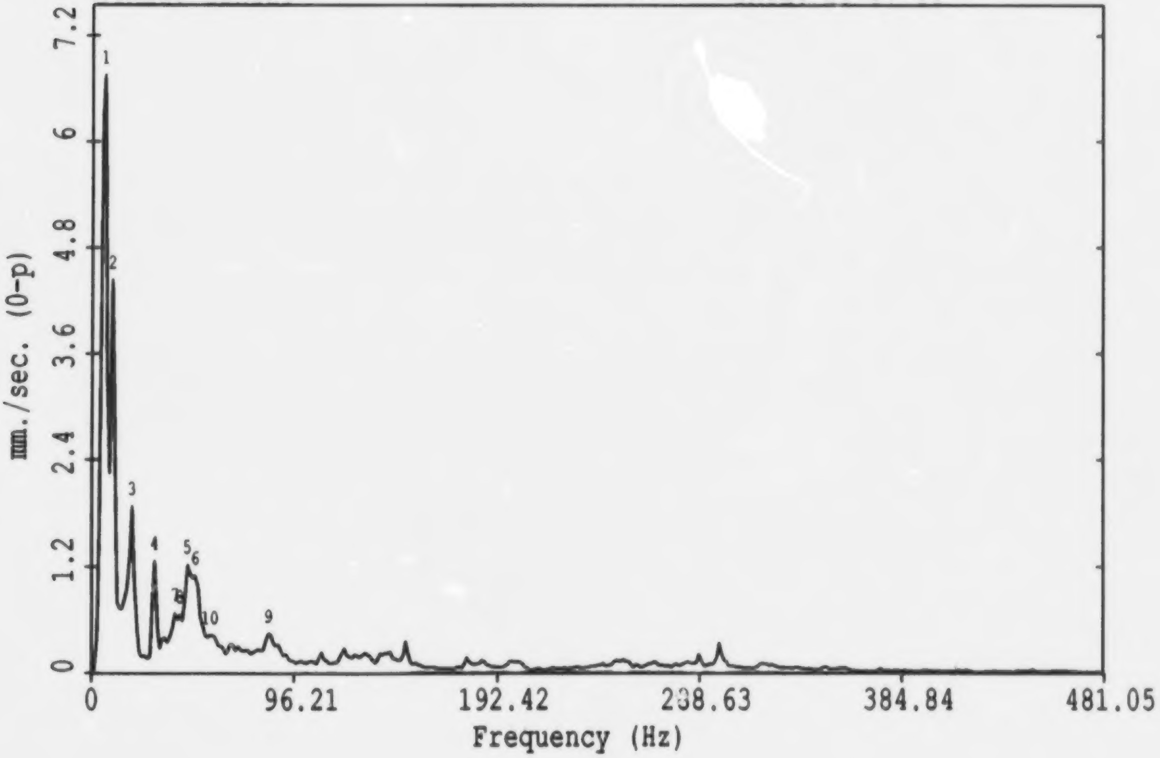


FIGURE 111

PNGS Unit 2 - ECIS Test #2 Moderator Pumpset Vibration

SIGNAL : Pumpset #1 - Pump Shaft Displacement E-W
PROCESS CONDITION : CIV Closure Test

PEAK NO.	FREQUENCY	AMPLITUDE
1	30.1	78.13
2	149.1	30.31
3	60.1	23.29
4	6.0	11.47
5	21.6	11.37
6	36.1	9.22
7	89.0	8.90
8	2.4	8.42
9	9.6	7.53
10	44.5	6.50

SCALE: Linear

DATE: 18-07-88

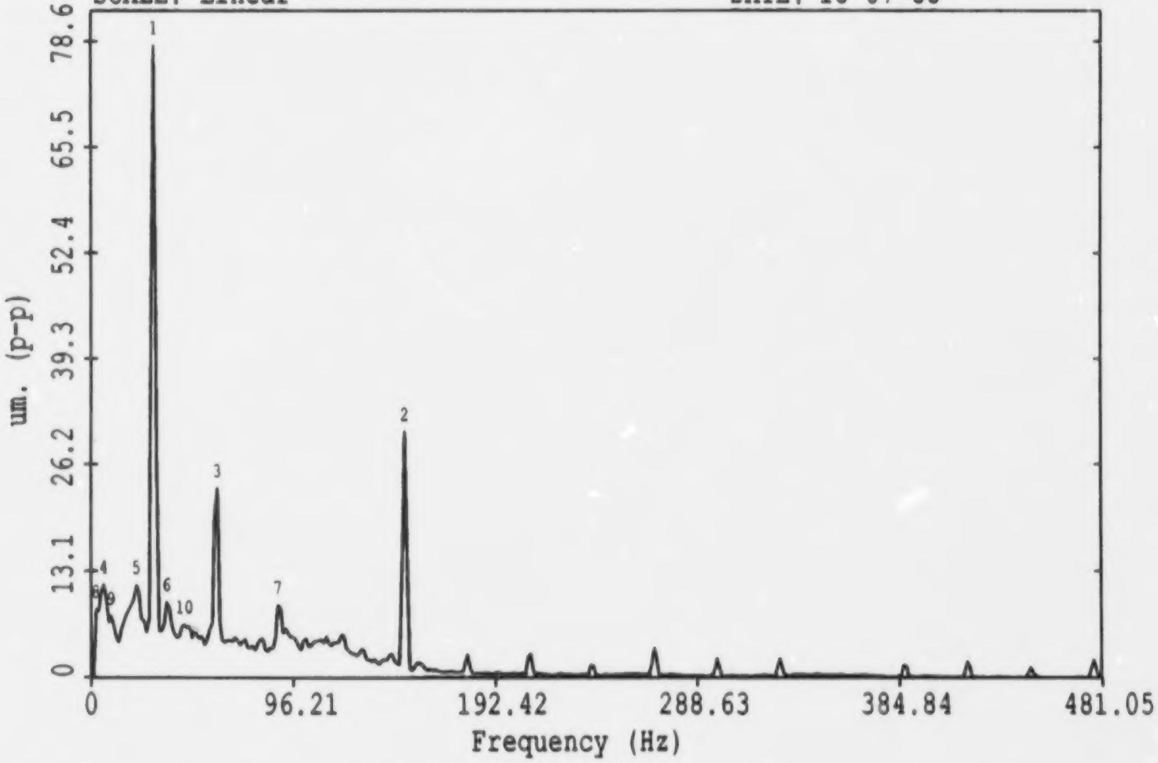


FIGURE 112

PNGS Unit 2 - ECIS Test #2 Moderator Pumpset Vibration

SIGNAL : Pumpset #1 - Pump Shaft Displacement N-S
PROCESS CONDITION : CIV Closure Test

PEAK NO.	FREQUENCY	AMPLITUDE
1	30.1	87.30
2	149.1	24.61
3	60.1	19.84
4	6.0	16.39
5	2.4	11.75
6	13.2	8.80
7	71.0	8.27
8	22.9	8.09
9	44.5	7.76
10	73.4	7.68

SCALE: Linear

DATE: 18-07-88

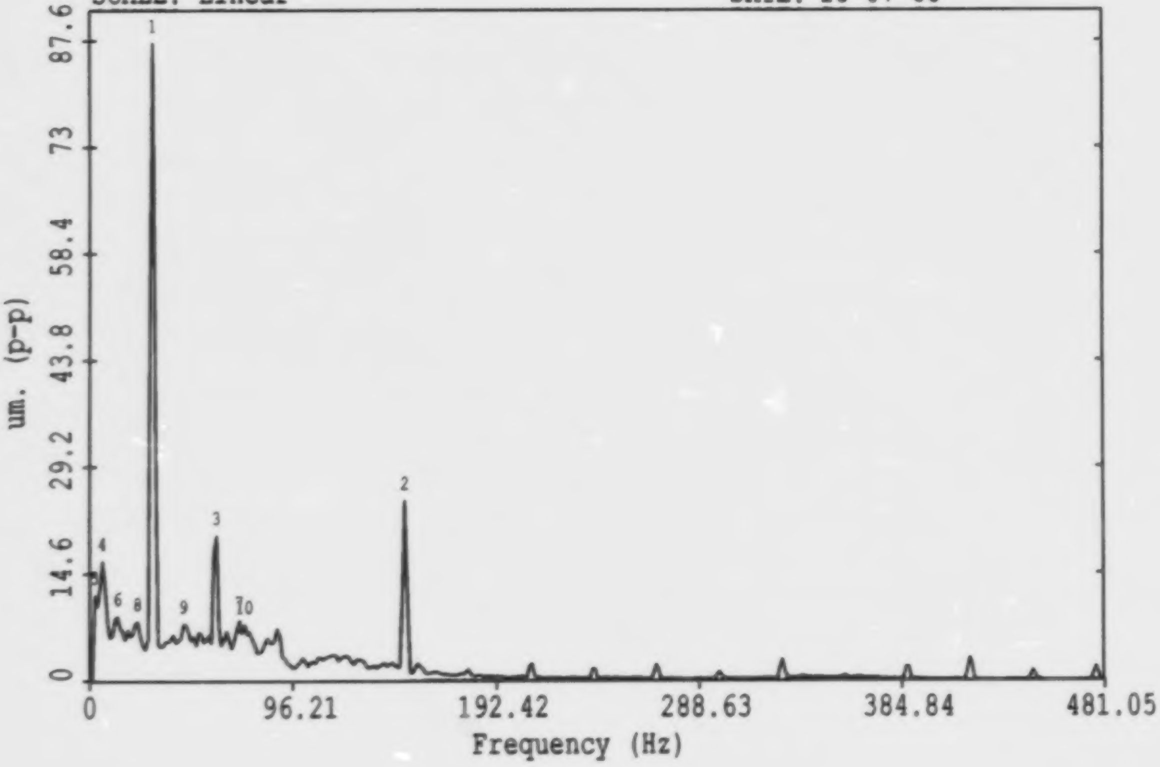


FIGURE 113

PNGS Unit 2 - ECIS Test #2 Moderator Pumpset Vibration

SIGNAL : Pumpset #2 - Pump Shaft Displacement E-W
PROCESS CONDITION : CIV Closure Test

PEAK NO.	FREQUENCY	AMPLITUDE
1	30.1	123.90
2	60.1	21.66
3	149.1	20.76
4	179.2	13.35
5	89.0	11.31
6	7.2	8.70
7	119.1	6.82
8	36.1	6.49
9	22.9	6.24
10	3.6	5.85

SCALE: Linear DATE: 18-07-88

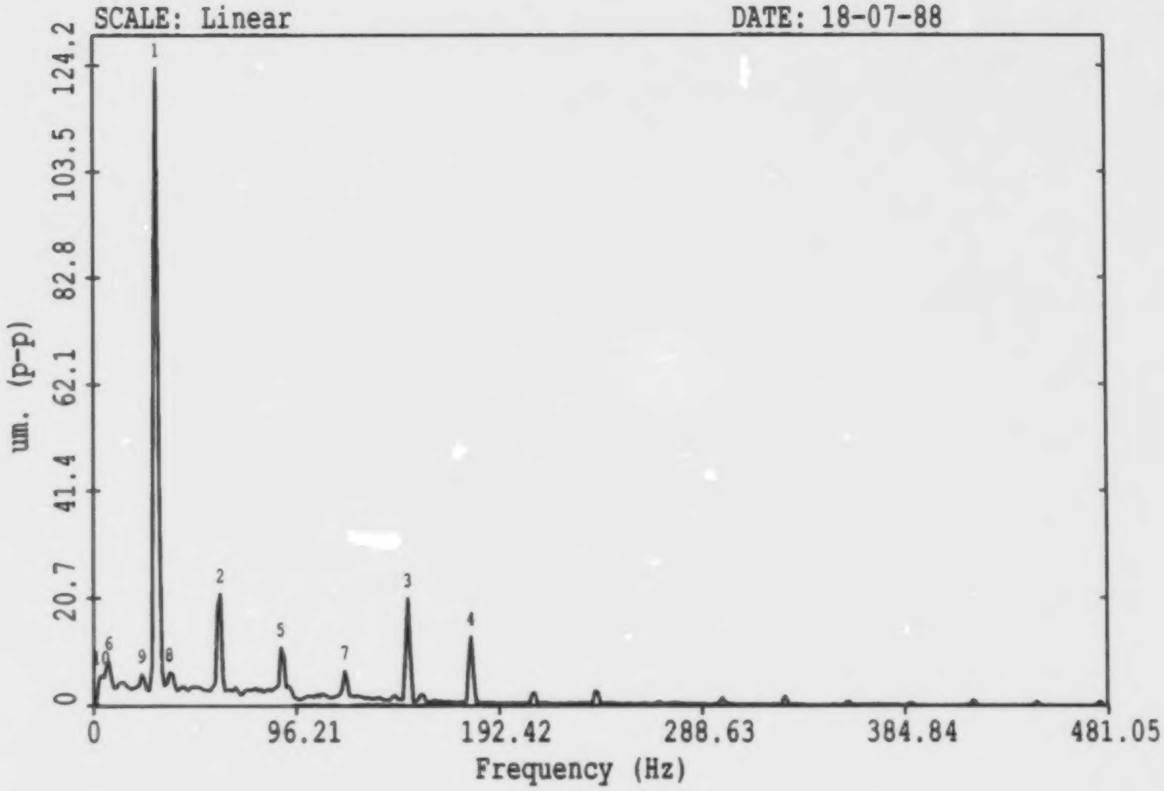


FIGURE 114

PNGS Unit 2 - ECIS Test #2 Moderator Pumpset Vibration

SIGNAL : Pumpset #2 - Pump Shaft Displacement N-S
PROCESS CONDITION : CIV Closure Test

PEAK NO.	FREQUENCY	AMPLITUDE
1	30.1	143.60
2	60.1	43.30
3	7.2	12.91
4	3.6	8.79
5	149.1	8.30
6	22.9	7.96
7	36.1	6.93
8	89.0	6.77
9	14.4	6.42
10	179.2	4.72

SCALE: Linear DATE: 18-07-88

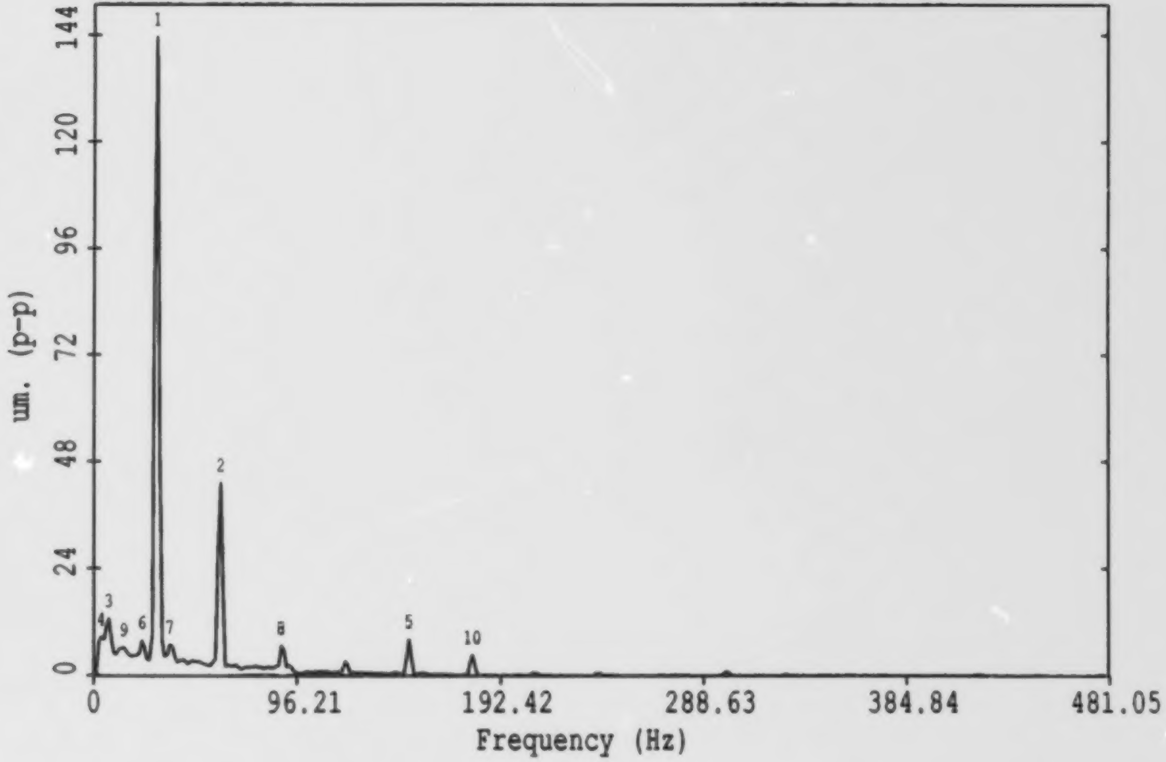


FIGURE 115

PNGS Unit 2 - ECIS Test #2 Moderator Pumpset Vibration

SIGNAL : Pumpset #3 - Pump Shaft Displacement E-W
PROCESS CONDITION : CIV Closure Test

PEAK NO.	FREQUENCY	AMPLITUDE
1	30.1	173.10
2	149.1	26.96
3	6.0	26.88
4	89.0	12.11
5	16.8	11.49
6	58.9	9.97
7	25.3	7.00
8	37.3	6.96
9	33.7	6.59
10	45.7	5.99

SCALE: Linear

DATE: 18-07-88

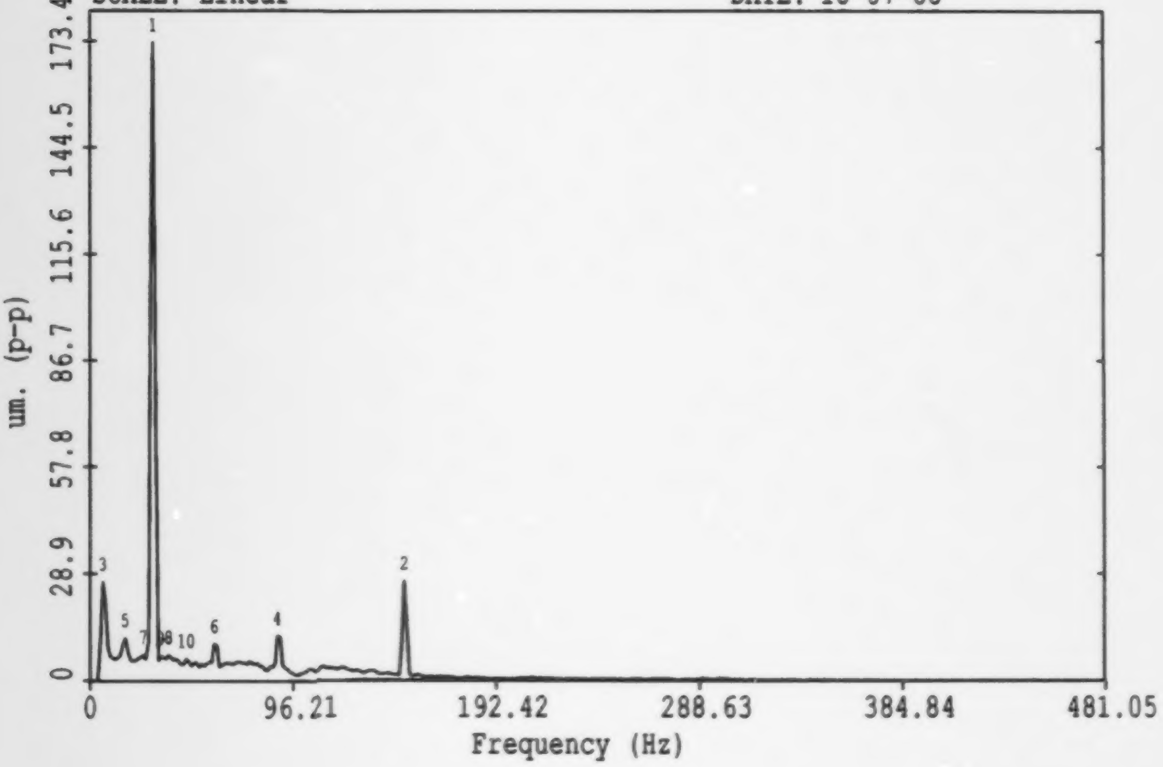


FIGURE 116

PNGS Unit 2 - ECIS Test #2 Moderator Pumpset Vibration

SIGNAL : Pumpset #4 - Pump Shaft Displacement E-W
PROCESS CONDITION : CIV Closure Test

PEAK NO.	FREQUENCY	AMPLITUDE
1	9.6	4.52
2	7.2	3.98
3	69.8	3.70
4	72.2	3.55
5	16.8	3.24
6	75.8	2.21
7	21.6	2.19
8	30.1	2.02
9	36.1	1.37
10	85.4	1.31

SCALE: Linear

DATE: 18-07-88

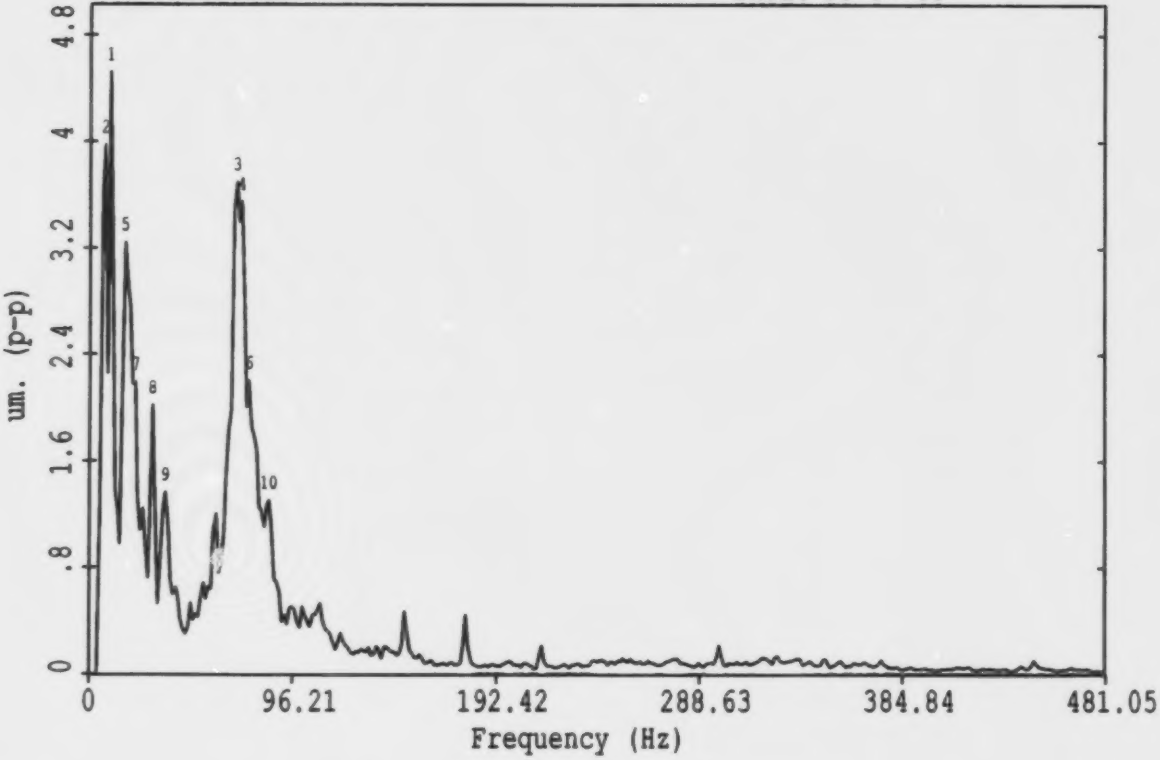


FIGURE 117

PNGS Unit 2 - ECIS Test #2 Moderator Pumpset Vibration

SIGNAL : Pumpset #5 - Pump Shaft Displacement E-W
PROCESS CONDITION : CIV Closure Test

PEAK NO.	FREQUENCY	AMPLITUDE
1	30.1	87.14
2	149.1	46.13
3	3.6	11.31
4	7.2	7.52
5	49.3	6.72
6	25.3	6.00
7	21.6	5.82
8	66.1	5.82
9	52.9	5.74
10	10.8	5.53

SCALE: Linear DATE: 18-07-88

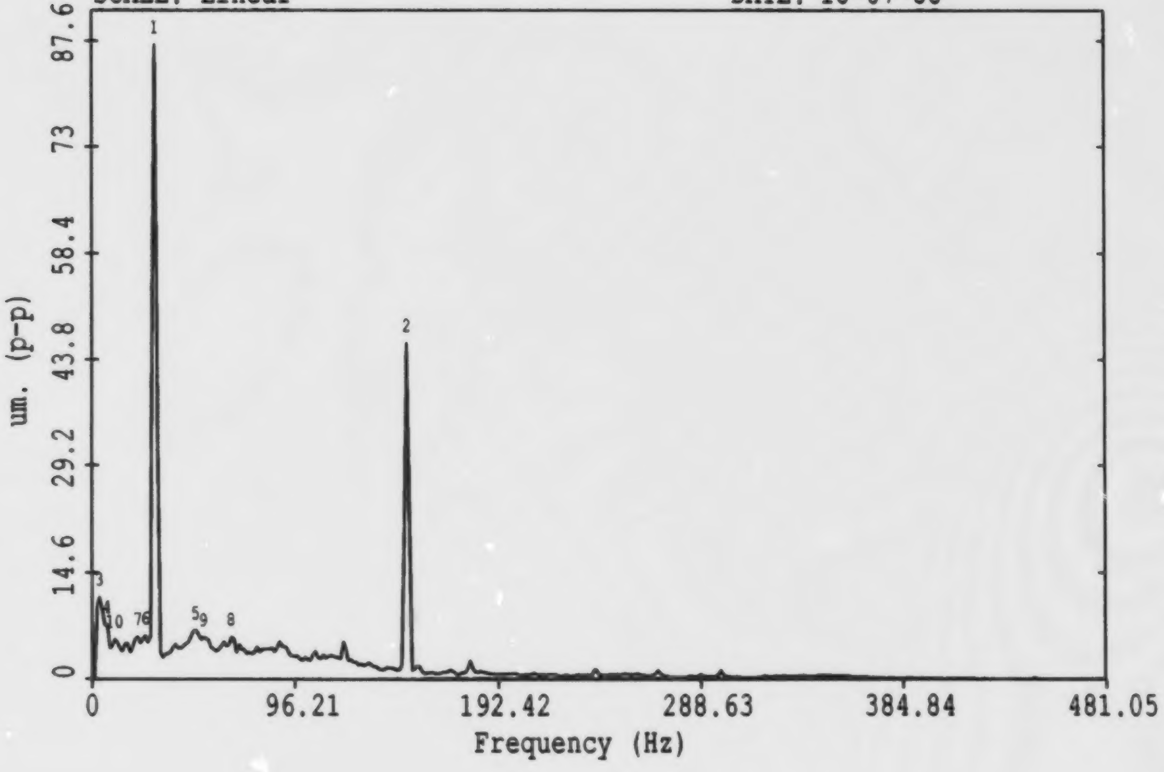
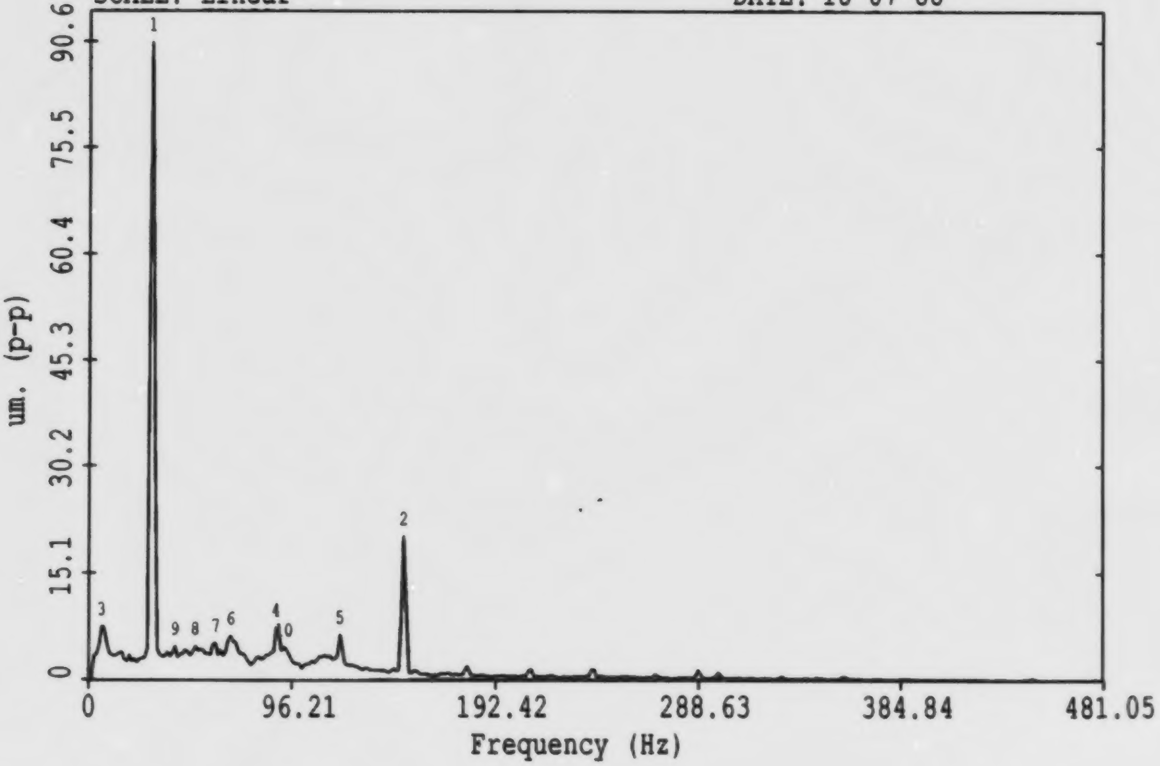


FIGURE 118

PNGS Unit 2 - ECIS Test #2 Moderator Pumpset Vibration

SIGNAL : Pumpset #5 - Pump Shaft Displacement N-S
PROCESS CONDITION : CIV Closure Test

PEAK NO.	FREQUENCY	AMPLITUDE
1	30.1	90.53
2	149.1	20.47
3	6.0	7.57
4	89.0	7.47
5	119.1	6.43
6	67.3	6.29
7	60.1	5.23
8	50.5	4.79
9	40.9	4.76
10	92.6	4.60



SCALE: Linear DATE: 18-07-88

FIGURE 119

PNGS Unit 2 - ECIS Test #2 Moderator Pumpset Vibration

SIGNAL : Expansion Joint #3 Vertical Velocity
PROCESS CONDITION : CIV Closure Test

PEAK NO.	FREQUENCY	AMPLITUDE
1	149.1	6.93
2	13.2	3.28
3	8.4	2.82
4	6.0	2.58
5	19.2	1.87
6	16.8	1.79
7	30.1	1.36
8	447.4	0.86
9	178.0	0.78
10	109.4	0.78

SCALE: Linear

DATE: 18-07-88

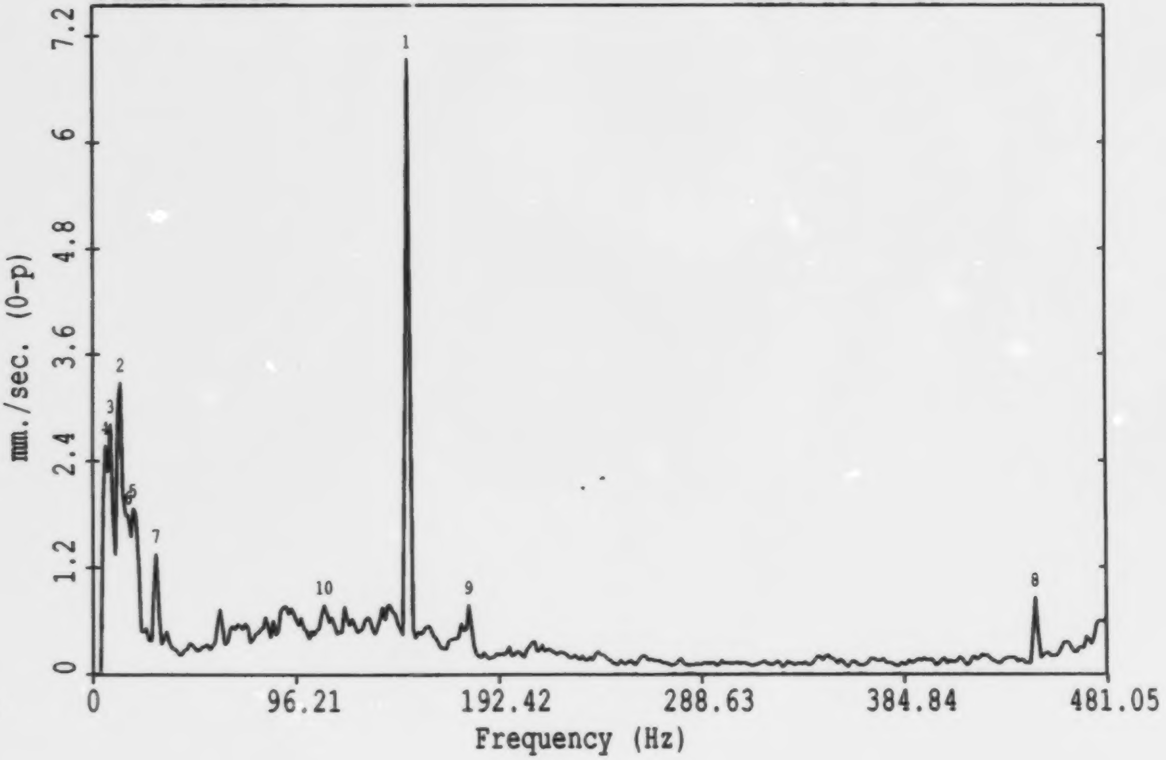


FIGURE 120

PNGS Unit 2 - ECIS Test #2 Moderator Pumpset Vibration

SIGNAL : Expansion Joint #3 Horizontal Velocity
PROCESS CONDITION : CIV Closure Test

PEAK NO.	FREQUENCY	AMPLITUDE
1	149.1	5.57
2	6.0	1.61
3	60.1	1.58
4	178.0	1.21
5	13.2	0.97
6	120.3	0.94
7	122.7	0.92
8	49.3	0.90
9	258.6	0.87
10	129.9	0.86

SCALE: Linear DATE: 18-07-88

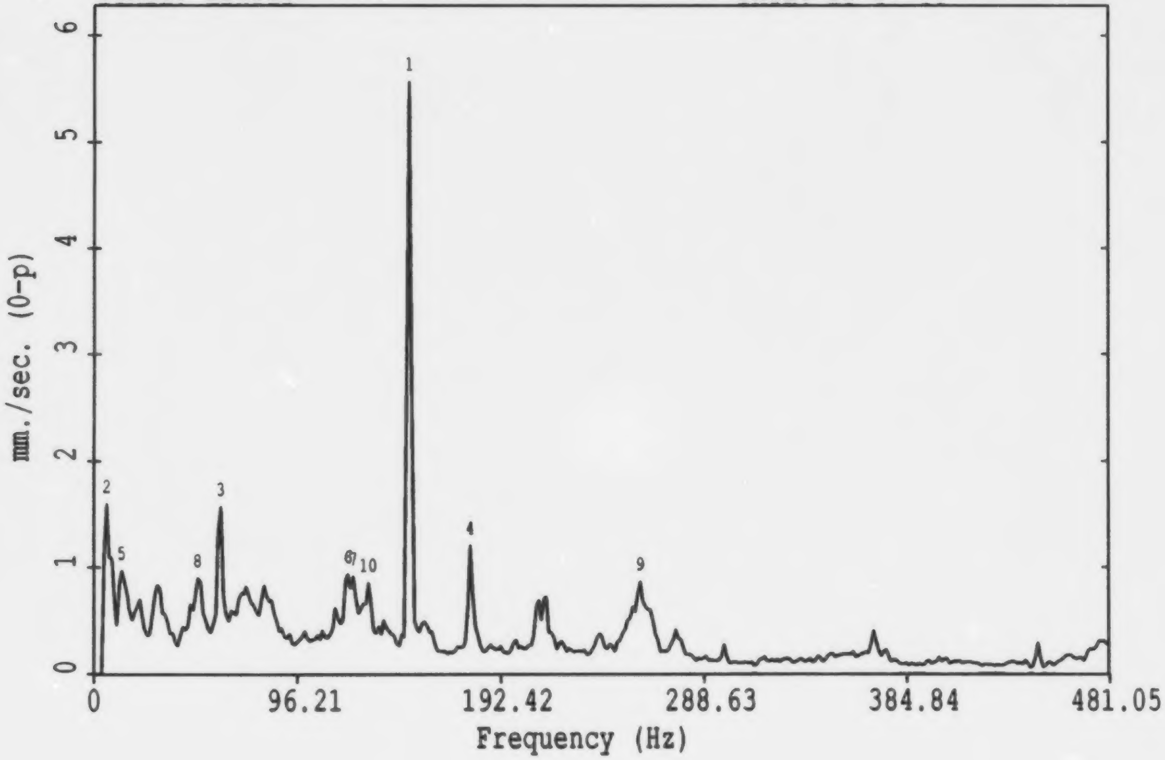


FIGURE 121

PNGS Unit 2 - ECIS Test #2 Moderator Pumpset Vibration

SIGNAL : Expansion Joint #3 Axial Velocity
PROCESS CONDITION : CIV Closure Test

PEAK NO.	FREQUENCY	AMPLITUDE
1	149.1	6.55
2	16.8	2.92
3	60.1	2.34
4	258.6	2.23
5	6.0	1.82
6	255.0	1.78
7	263.4	1.73
8	119.1	1.26
9	24.1	1.22
10	214.1	1.18

SCALE: Linear

DATE: 18-07-88

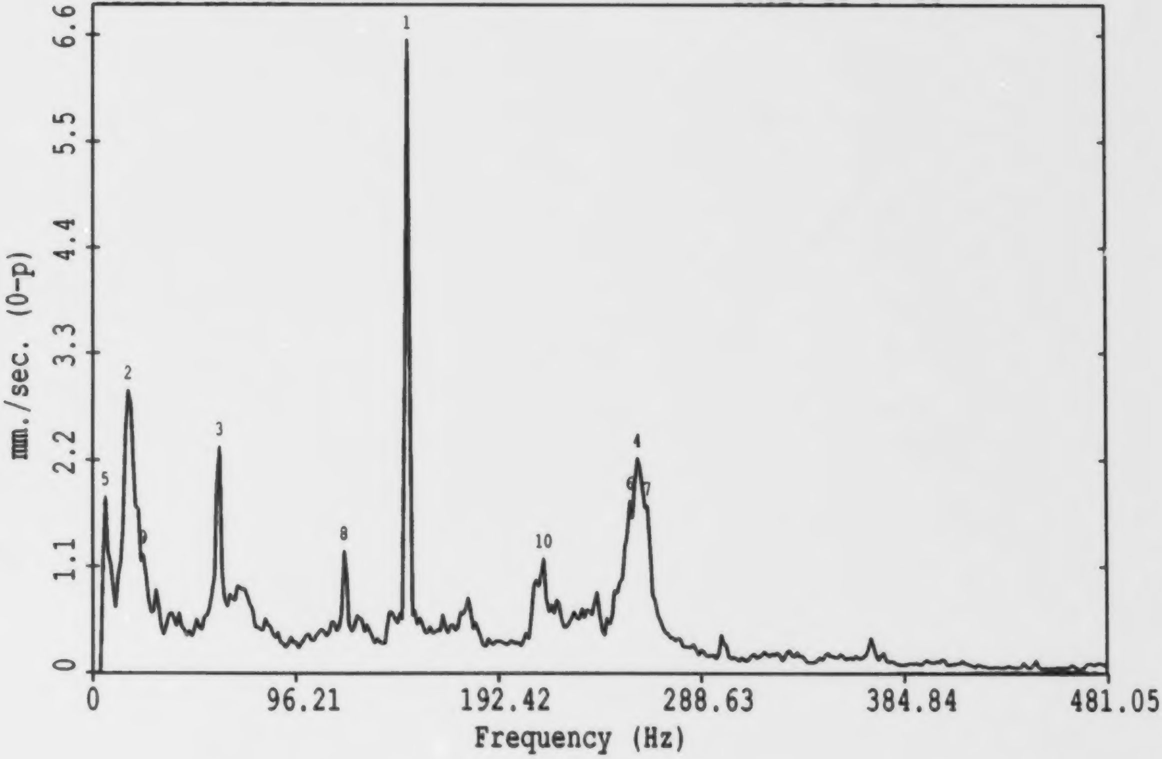


FIGURE 122

PNGS Unit 2 - ECIS Test #2 Moderator Pumpset Vibration

SIGNAL : Expansion Joint #4 Horizontal Velocity
PROCESS CONDITION : CIV Closure Test

PEAK NO.	FREQUENCY	AMPLITUDE
1	19.2	6.23
2	9.6	2.25
3	149.1	2.24
4	6.0	2.14
5	60.1	1.55
6	48.1	0.92
7	68.6	0.84
8	42.1	0.81
9	64.9	0.75
10	298.3	0.70

SCALE: Linear

DATE: 18-07-88

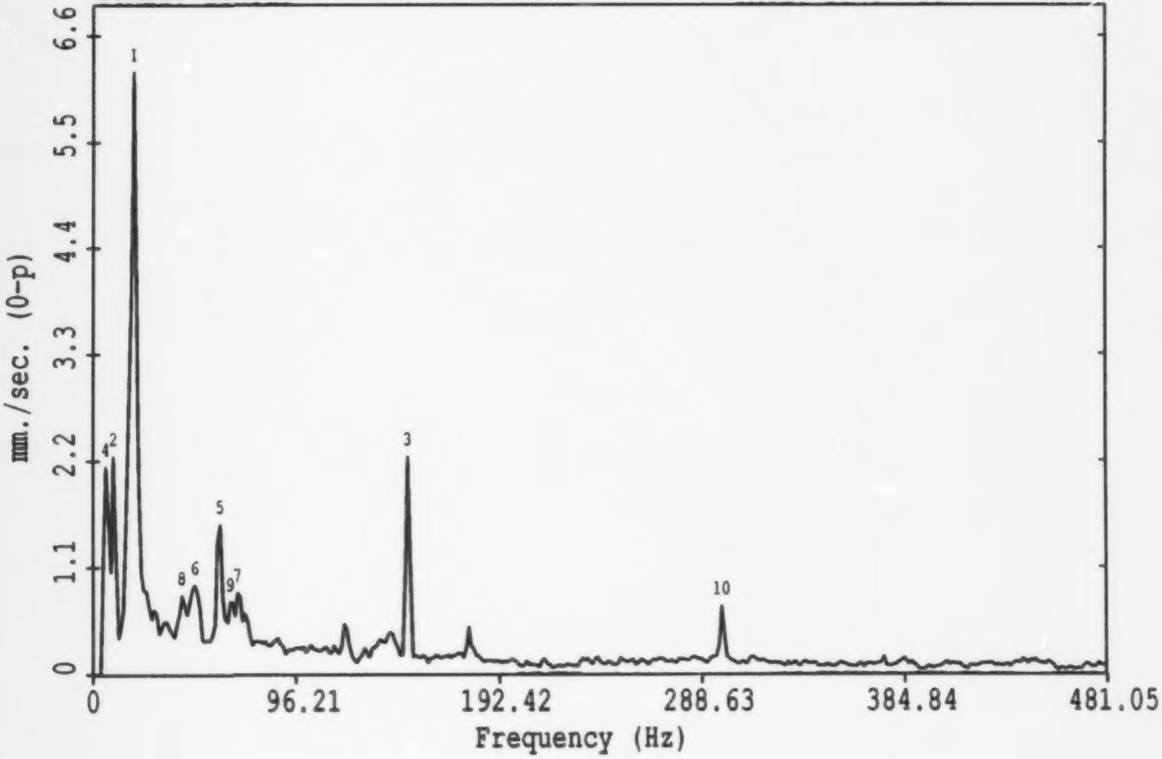


FIGURE 123

PNGS Unit 2 - ECIS Test #2 Moderator Pumpset Vibration

SIGNAL : Expansion Joint #4 Axial Velocity
PROCESS CONDITION : CIV Closure Test

PEAK NO.	FREQUENCY	AMPLITUDE
1	149.1	3.51
2	69.8	2.49
3	72.2	2.37
4	66.1	1.88
5	30.1	1.53
6	6.0	1.50
7	19.2	1.44
8	77.0	1.31
9	21.6	1.18
10	36.1	1.18

SCALE: Linear

DATE: 18-07-88

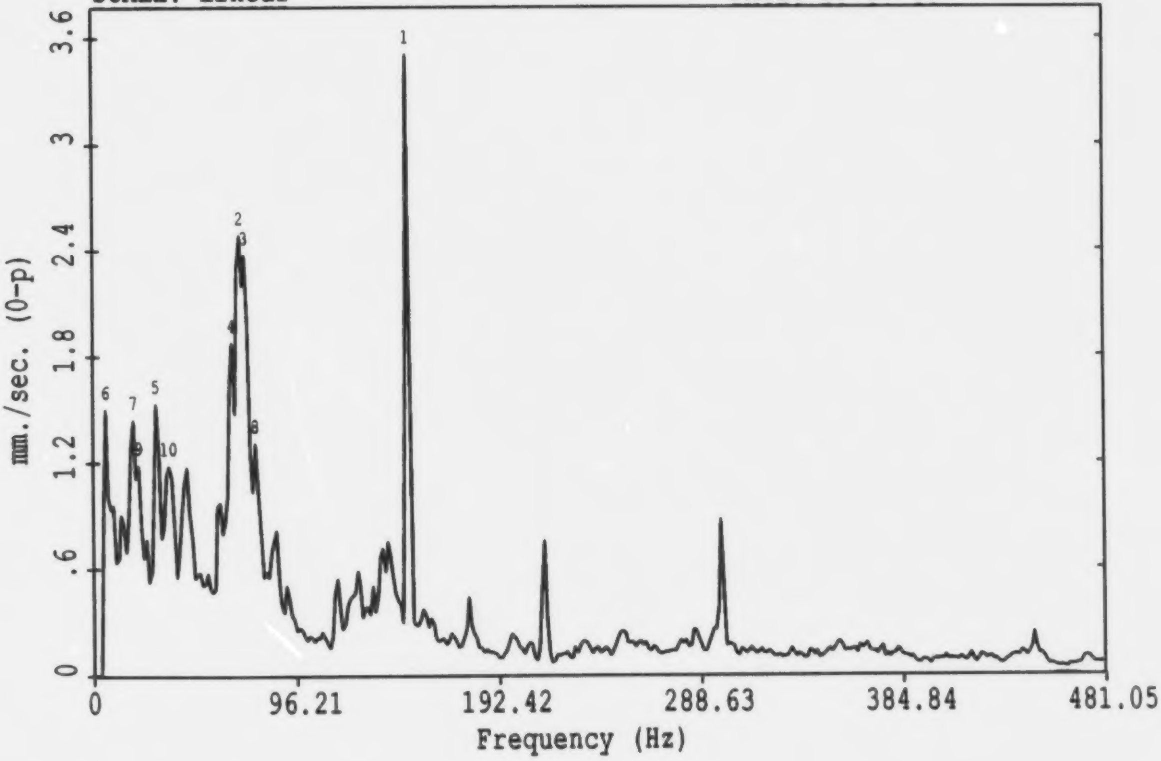


FIGURE 124

PNGS Unit 2 - ECIS Test #3 Moderator Pumpset Vibration

SIGNAL : Pumpset #1 - Motor Casing Vel N-S
PROCESS CONDITION : Dump Test

PEAK NO.	FREQUENCY	AMPLITUDE
1	4.8	1.85
2	30.1	1.62
3	58.9	0.75
4	178.0	0.46
5	89.0	0.41
6	12.0	0.35
7	16.8	0.32
8	66.1	0.31
9	119.1	0.29
10	149.1	0.28

SCALE: Linear

DATE: 19-07-88

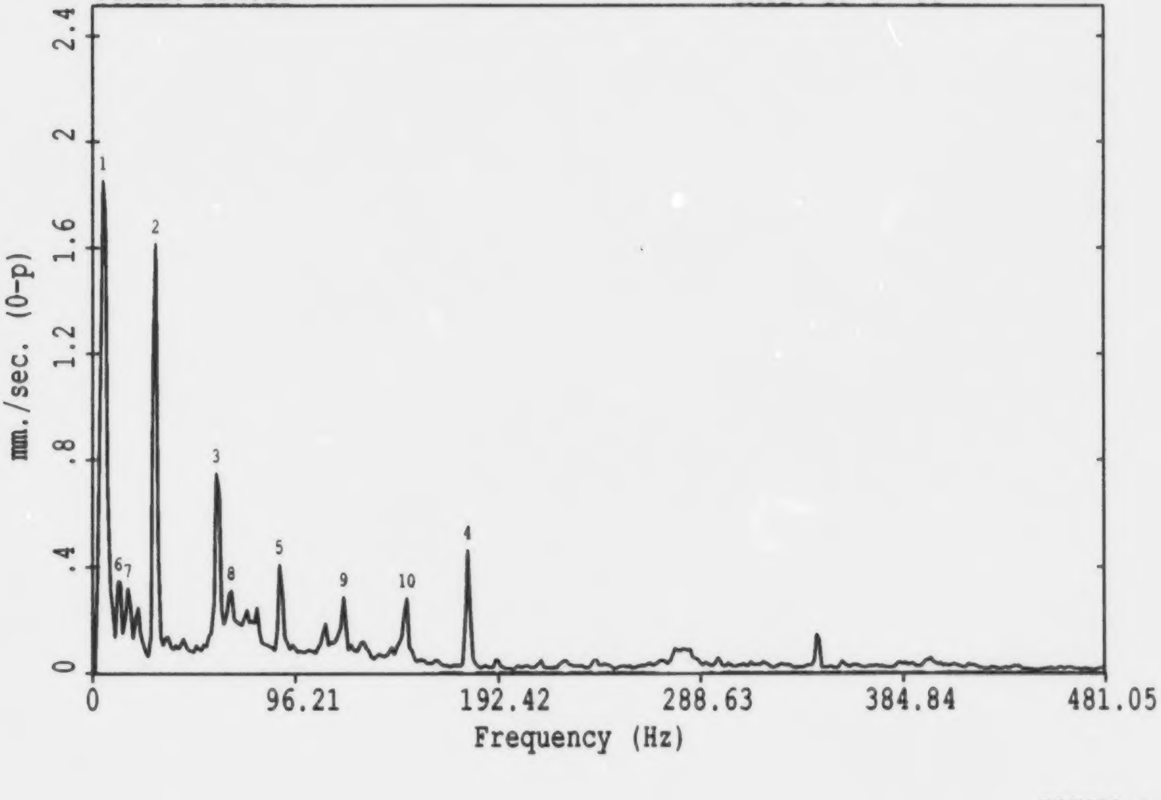


FIGURE 125

PNGS Unit 2 - ECIS Test #3 Moderator Pumpset Vibration

SIGNAL : Pumpset #2 - Motor Casing Vel E-W
PROCESS CONDITION : Dump Test

PEAK NO.	FREQUENCY	AMPLITUDE
1	9.6	1.51
2	30.1	1.08
3	3.6	0.78
4	119.1	0.50
5	149.1	0.40
6	123.9	0.39
7	16.8	0.34
8	110.6	0.32
9	89.0	0.32
10	128.7	0.29

SCALE: Linear DATE: 19-07-88

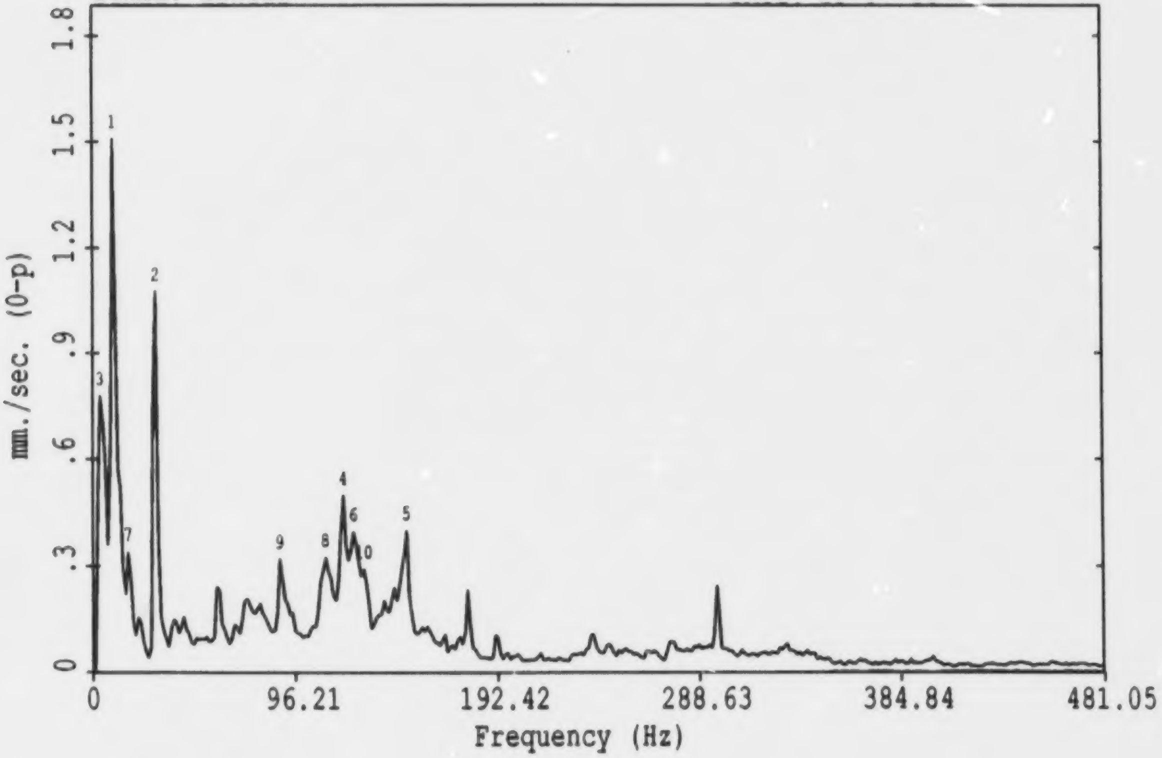


FIGURE 126

PNGS Unit 2 - ECIS Test #3 Moderator Pumpset Vibration

SIGNAL : Pumpset #2 - Motor Casing Vel N-S
PROCESS CONDITION : Dump Test

PEAK NO.	FREQUENCY	AMPLITUDE
1	30.1	2.68
2	6.0	2.03
3	[illegible].9	0.80
4	16.8	0.41
5	89.0	0.34
6	13.2	0.29
7	147.9	0.23
8	178.0	0.23
9	81.8	0.21
10	21.6	0.20

SCALE: Linear

DATE: 19-07-88

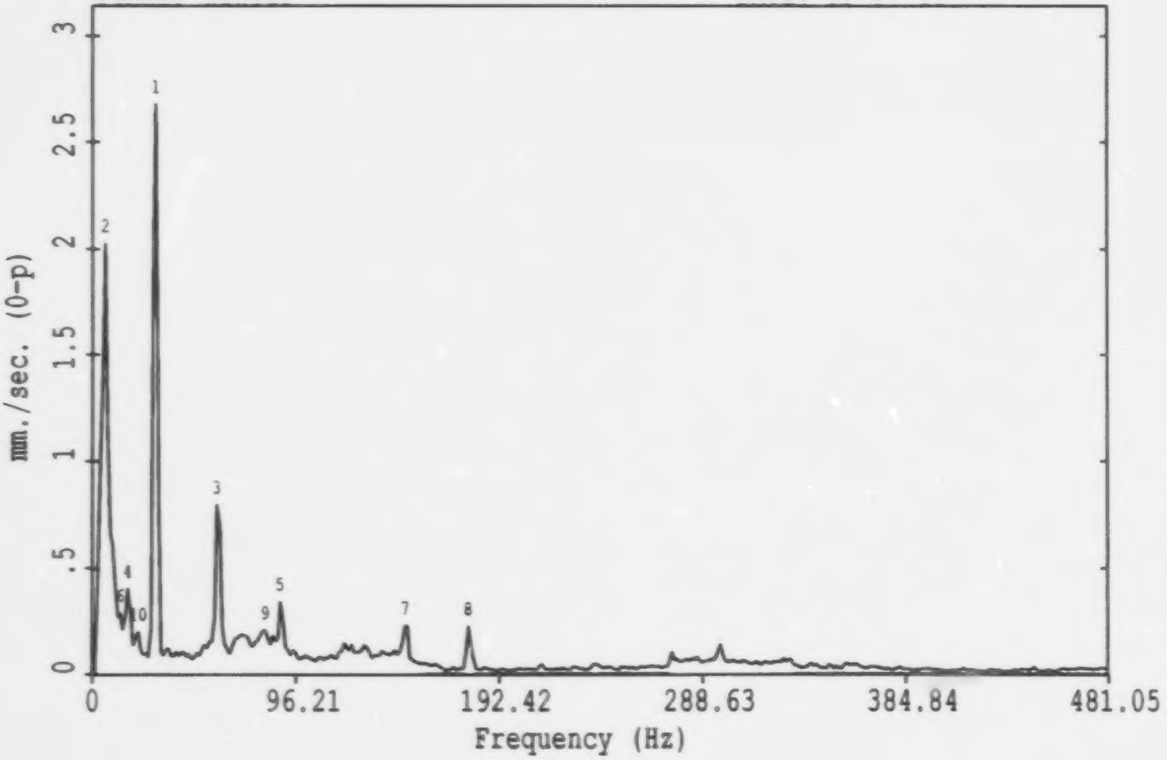


FIGURE 127

PNGS Unit 2 - ECIS Test #3 Moderator Pumpset Vibration

SIGNAL : Pumpset #3 - Motor Casing Velocity N-S
PROCESS CONDITION : Dump Test

PEAK NO.	FREQUENCY	AMPLITUDE
1	30.1	1.92
2	7.2	1.40
3	58.9	0.61
4	200.8	0.33
5	79.4	0.29
6	297.1	0.26
7	149.1	0.26
8	16.8	0.25
9	68.6	0.25
10	12.0	0.24

SCALE: Linear

DATE: 19-07-88

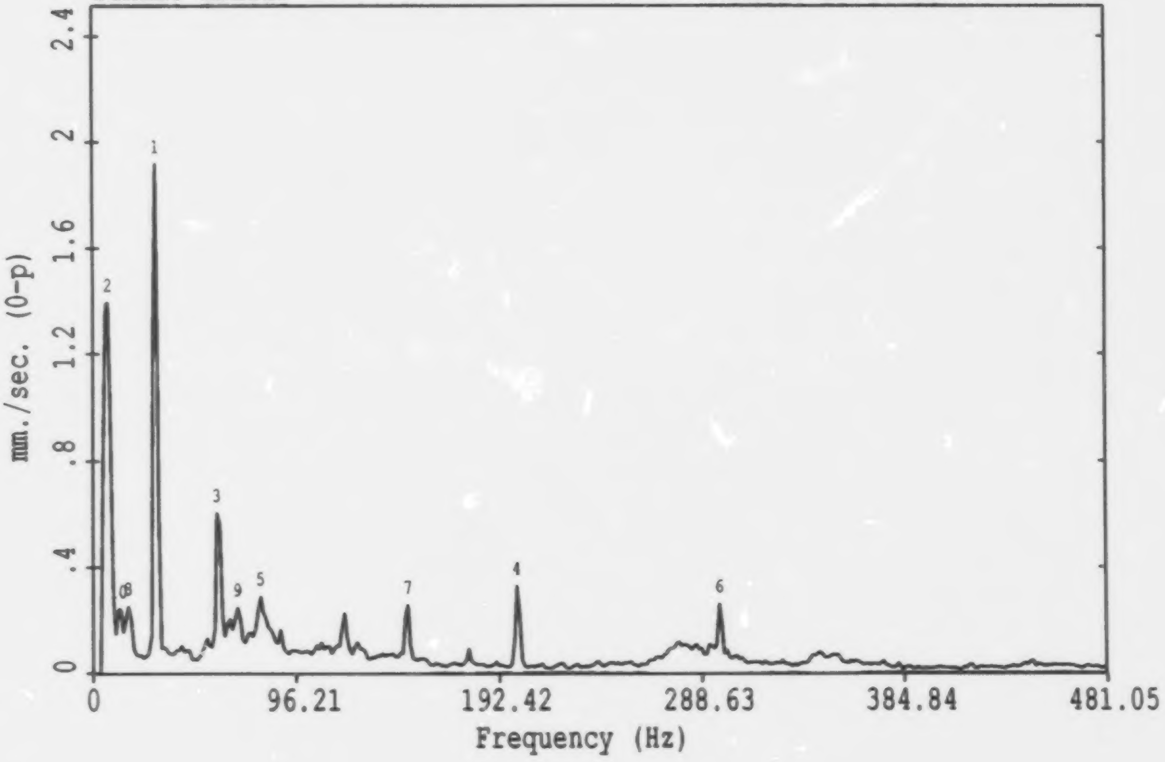


FIGURE 128

PNGS Unit 2 - ECIS Test #3 Moderator Pumpset Vibration

SIGNAL : Pumpset #4 - Motor Casing Velocity E-W
PROCESS CONDITION : Dump Test

PEAK NO.	FREQUENCY	AMPLITUDE
1	30.1	1.72
2	7.2	1.47
3	16.8	0.99
4	9.6	0.71
5	21.6	0.28
6	89.0	0.22
7	58.9	0.20
8	200.8	0.19
9	149.1	0.14
10	178.0	0.13

SCALE: Linear DATE: 19-07-88

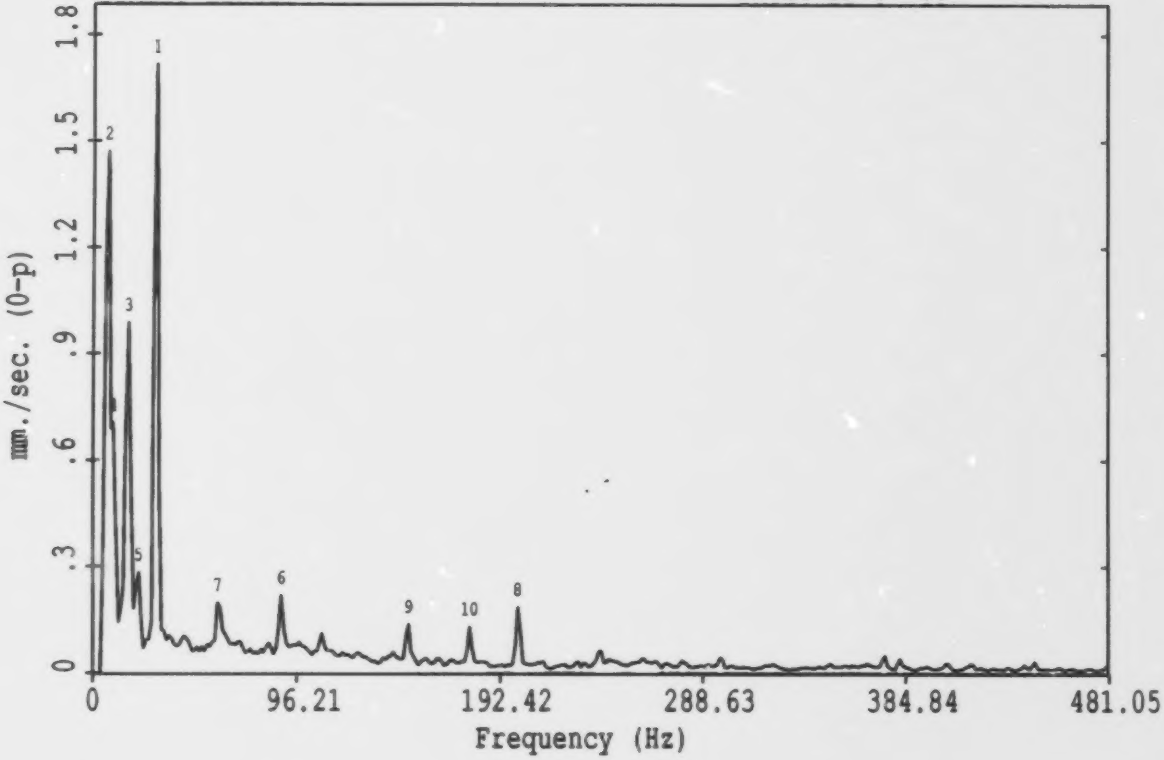


FIGURE 129

PNGS Unit 2 - ECIS Test #3 Moderator Pumpset Vibration

SIGNAL : Pumpset #5 - Motor Casing Vel E-W
PROCESS CONDITION : Dump Test

PEAK NO.	FREQUENCY	AMPLITUDE
1	30.1	4.45
2	7.2	0.93
3	19.2	0.89
4	9.6	0.71
5	2.4	0.47
6	15.6	0.35
7	291.0	0.34
8	60.1	0.31
9	297.1	0.28
10	45.7	0.25

SCALE: Linear

DATE: 19-07-88

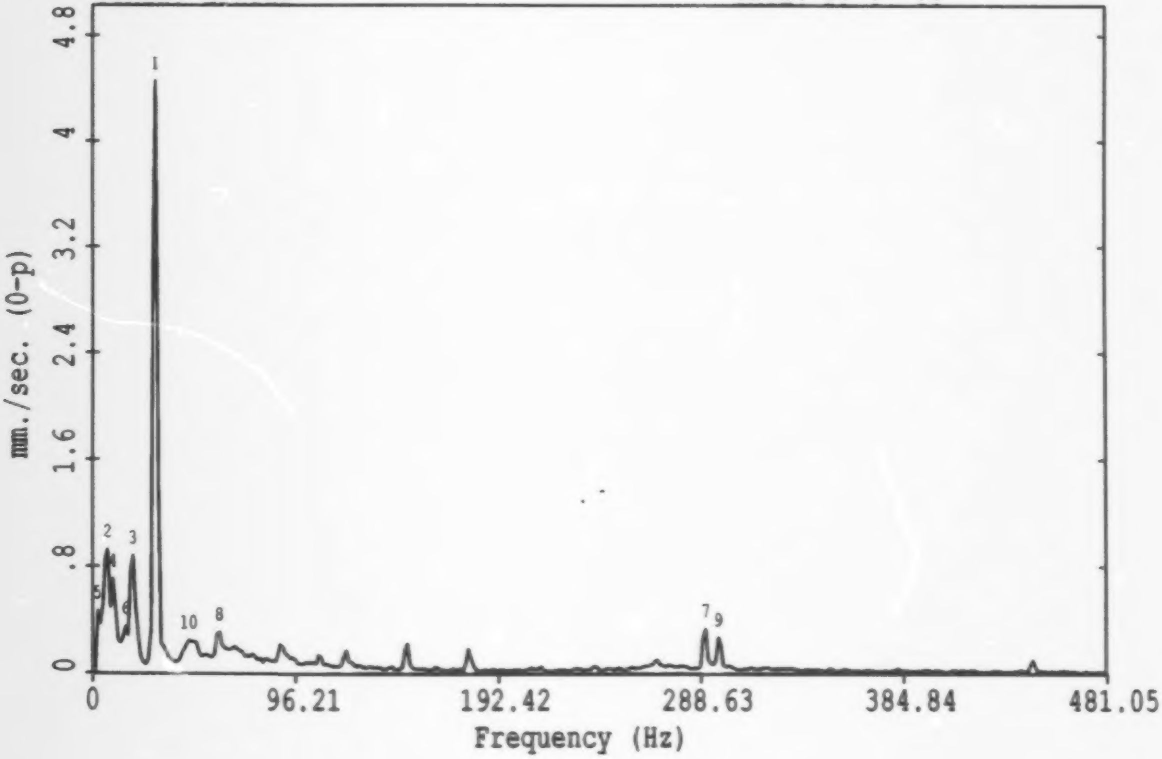


FIGURE 130

PNGS Unit 2 - ECIS Test #3 Moderator Pumpset Vibration

SIGNAL : Pumpset #5 - Motor Casing Vel N-S
PROCESS CONDITION : Dump Test

PEAK NO.	FREQUENCY	AMPLITUDE
1	9.6	1.27
2	30.1	1.23
3	4.8	0.74
4	19.2	0.45
5	15.6	0.40
6	58.9	0.35
7	2.4	0.35
8	48.1	0.27
9	45.7	0.27
10	297.1	0.25

SCALE: Linear DATE: 19-07-88

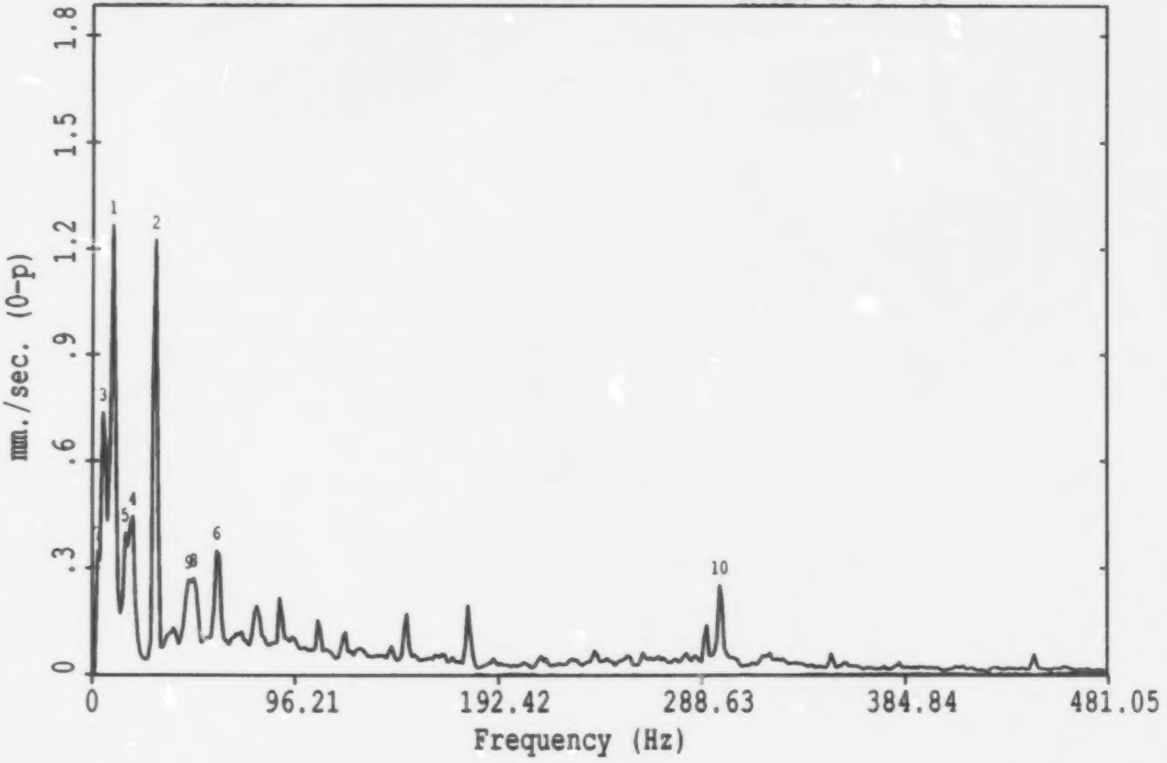


FIGURE 131

PNGS Unit 2 - ECIS Test #3 Moderator Pumpset Vibration

SIGNAL : Pumpset #1 - Pump Shaft Displacement E-W
PROCESS CONDITION : Dump Test

PEAK NO.	FREQUENCY	AMPLITUDE
1	30.1	37.26
2	58.9	21.42
3	149.1	14.07
4	89.0	12.08
5	2.4	8.33
6	119.1	4.30
7	267.0	3.32
8	208.1	3.30
9	110.6	2.89
10	178.0	2.88

SCALE: Linear

DATE: 19-07-88

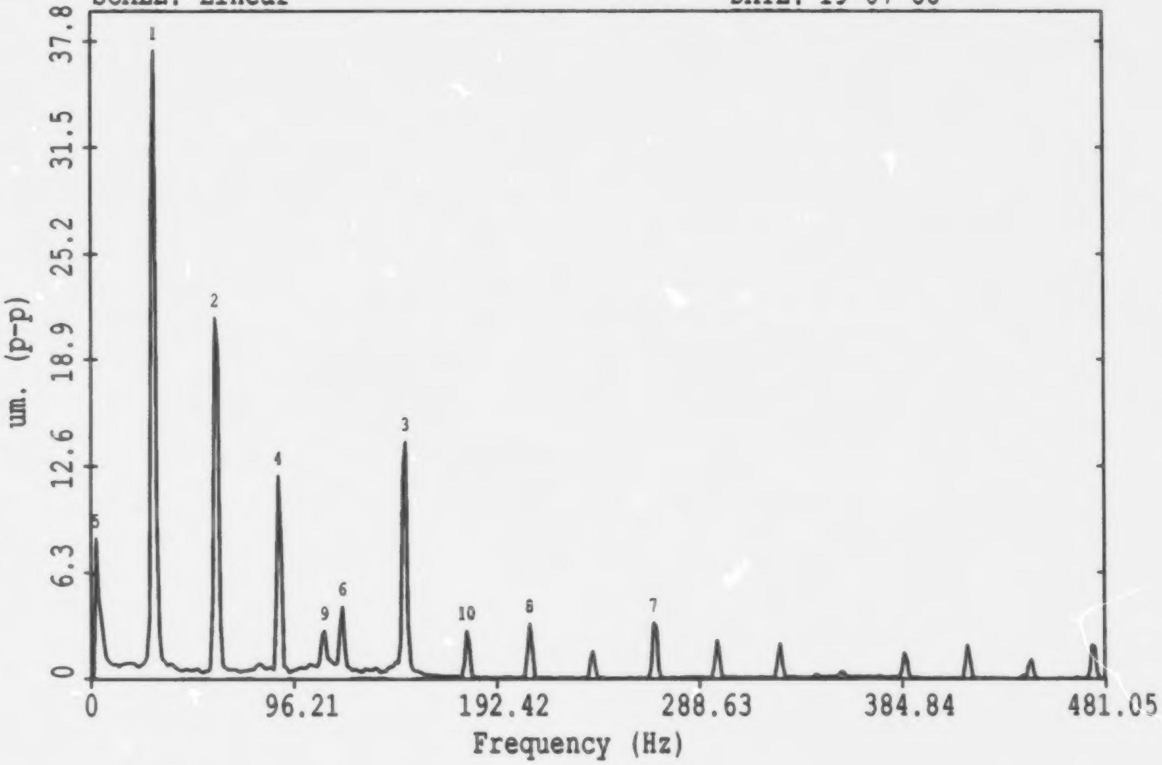


FIGURE 132

PNGS Unit 2 - ECIS Test #3 Moderator Pumpset Vibration

SIGNAL : Pumpset #1 - Pump Shaft Displacement N-S
PROCESS CONDITION : Dump Test

PEAK NO.	FREQUENCY	AMPLITUDE
1	30.1	48.16
2	58.9	15.05
3	149.1	8.95
4	119.1	5.25
5	4.8	4.32
6	89.0	4.08
7	416.1	3.14
8	327.1	3.06
9	110.6	2.69
10	208.1	2.33

SCALE: Linear

DATE: 19-07-88

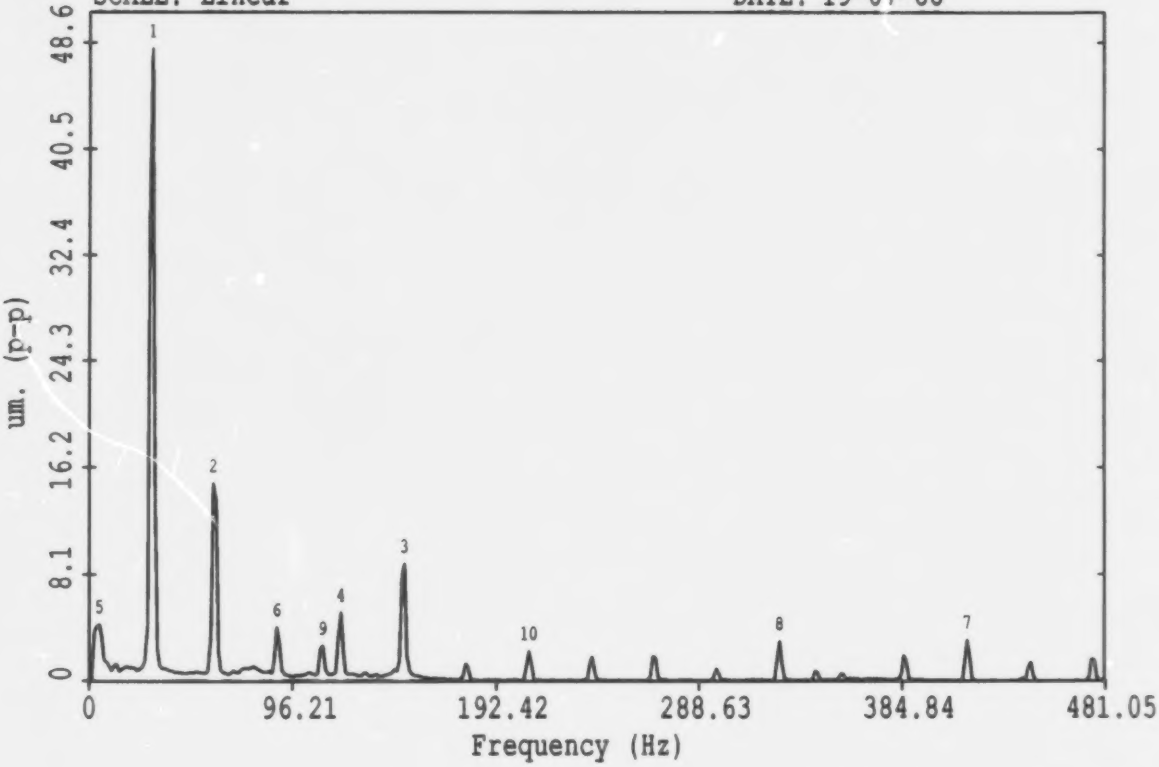
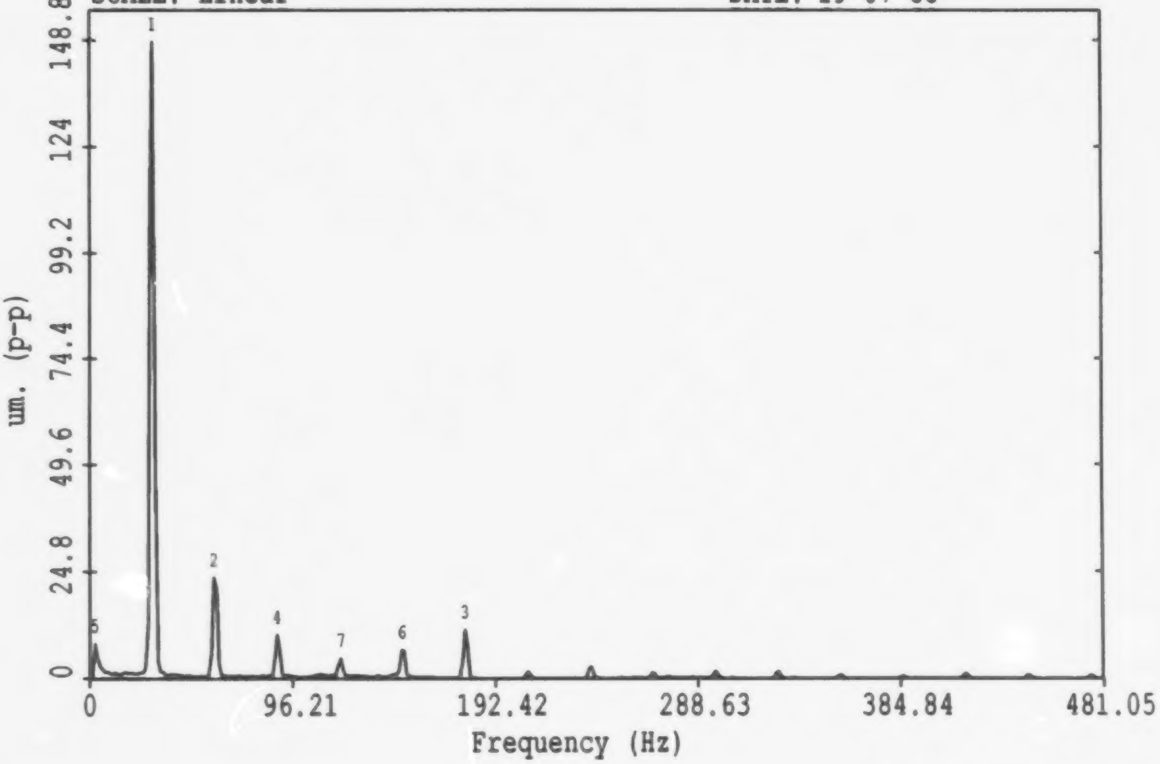


FIGURE 133

PNGS Unit 2 - ECIS Test #3 Moderator Pumpset Vibration

SIGNAL : Pumpset #2 - Pump Shaft Displacement E-W
PROCESS CONDITION : Dump Test

PEAK NO.	FREQUENCY	AMPLITUDE
1	30.1	148.50
2	58.9	23.51
3	178.0	11.40
4	89.0	10.17
5	2.4	8.07
6	147.9	6.70
7	119.1	4.84



SCALE: Linear DATE: 19-07-88

FIGURE 134

PNGS Unit 2 - ECIS Test #3 Moderator Pumpset Vibration

SIGNAL : Pumpset #2 - Pump Shaft Displacement N-S
PROCESS CONDITION : Dump Test

PEAK NO.	FREQUENCY	AMPLITUDE
1	30.1	173.60
2	60.1	45.21
3	2.4	12.20
4	89.0	5.99
5	178.0	3.82

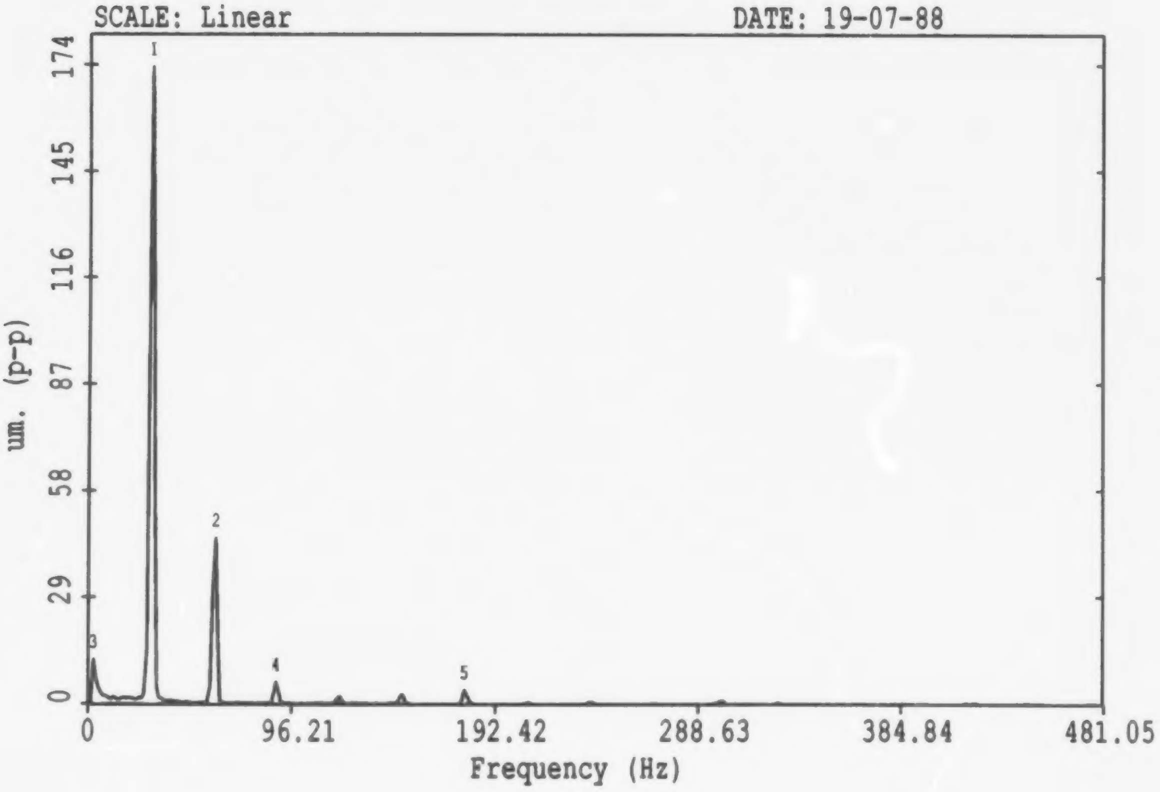


FIGURE 135

PNGS Unit 2 - ECIS Test #3 Moderator Pumpset Vibration

SIGNAL : Pumpset #3 - Pump Shaft Displacement E-W
PROCESS CONDITION : Dump Test

PEAK NO.	FREQUENCY	AMPLITUDE
1	30.1	184.80
2	58.9	11.94
3	89.0	8.52
4	149.1	4.43

SCALE: Linear DATE: 19-07-88

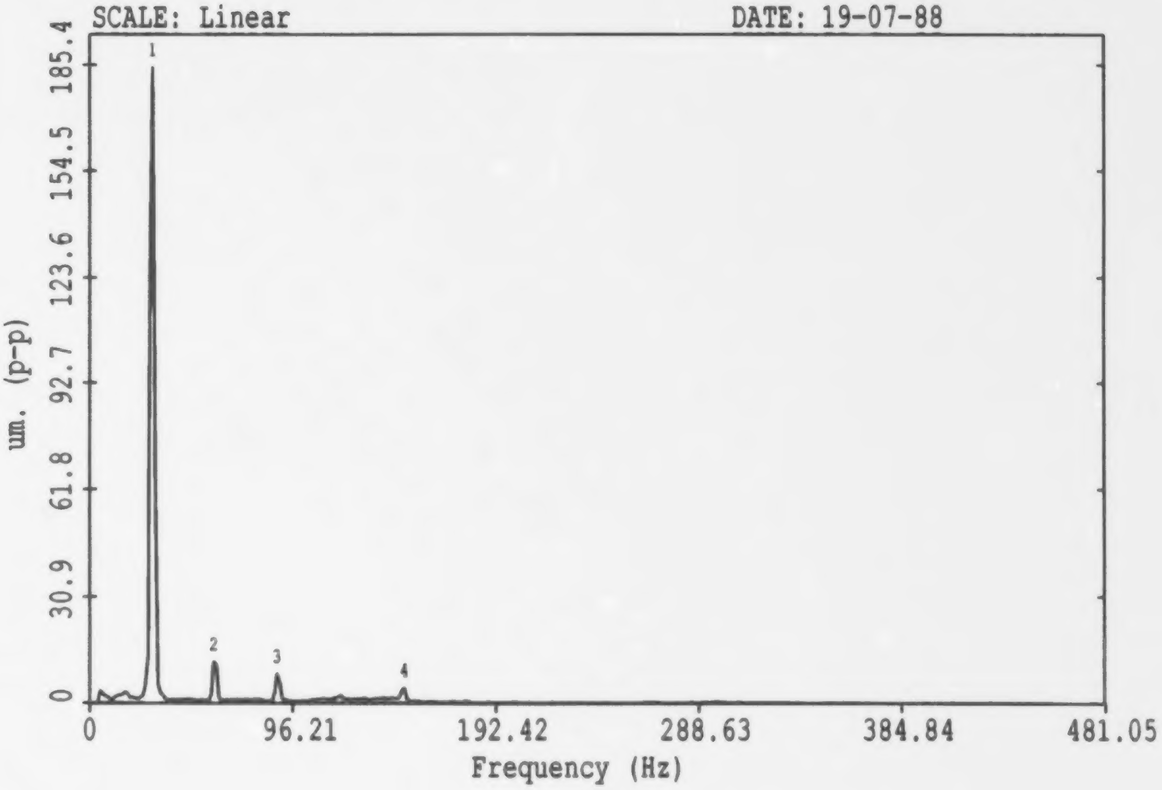


FIGURE 136

PNGS Unit 2 - ECIS Test #3 Moderator Pumpset Vibration

SIGNAL : Pumpset #4 - Pump Shaft Displacement E-W
PROCESS CONDITION : Dump Test

PEAK NO.	FREQUENCY	AMPLITUDE
1	9.6	2.10
2	16.8	1.93
3	89.0	1.58
4	7.2	1.28
5	30.1	0.89
6	60.1	0.84
7	21.6	0.75
8	69.8	0.51
9	119.1	0.49
10	78.2	0.47

SCALE: Linear

DATE: 19-07-88

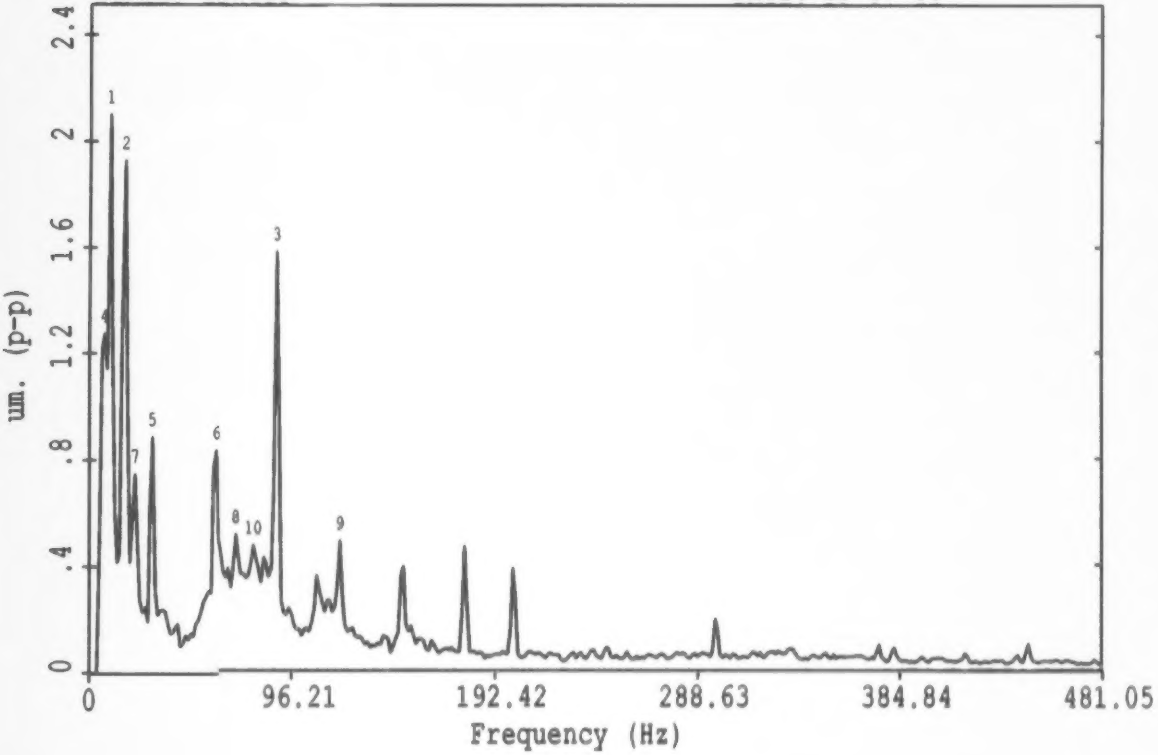


FIGURE 137

PNGS Unit 2 - ECIS Test #3 Moderator Pumpset Vibration

SIGNAL : Pumpset #5 - Pump Shaft Displacement E-W
PROCESS CONDITION : Dump Test

PEAK NO.	FREQUENCY	AMPLITUDE
1	30.1	138.60
2	2.4	9.48
3	149.1	8.99

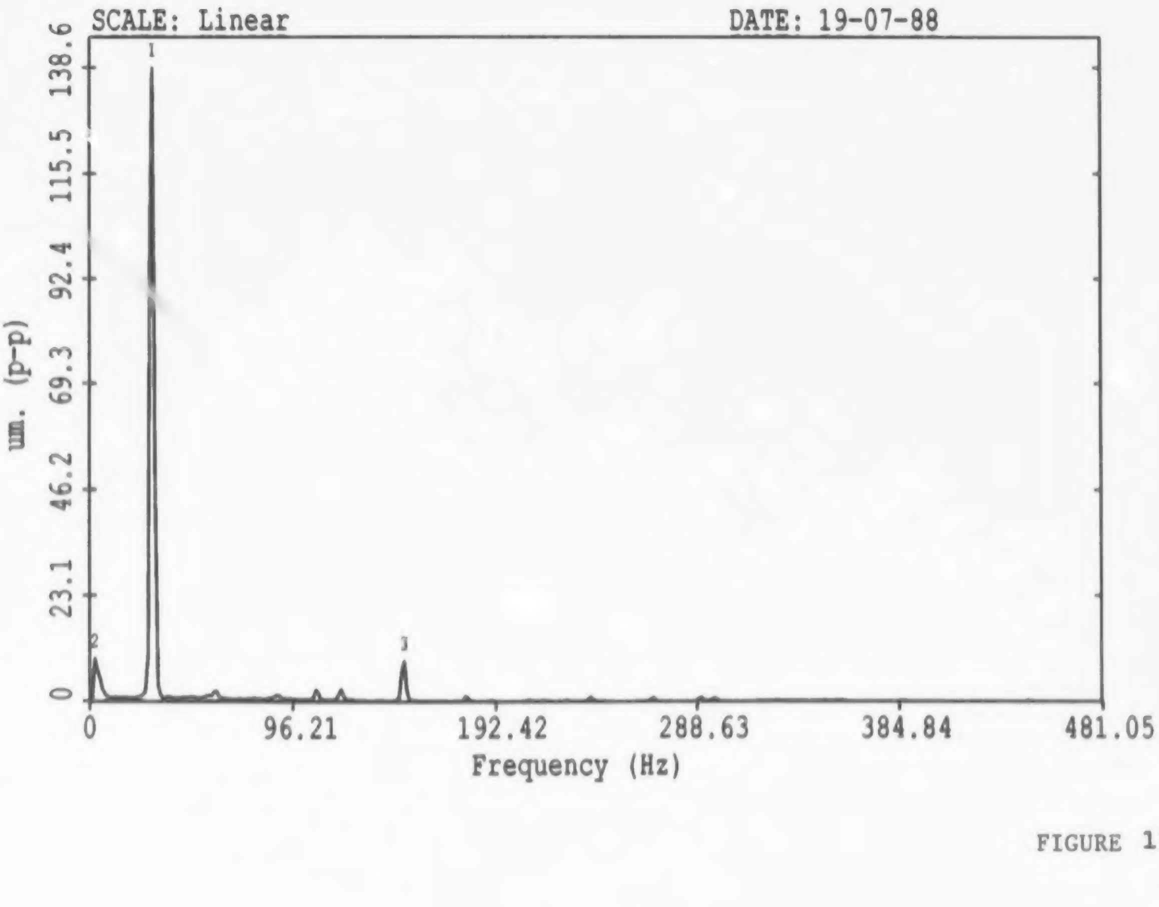


FIGURE 138

PNGS Unit 2 - ECIS Test #3 Moderator Pumpset Vibration

SIGNAL : Pumpset #5 - Pump Shaft Displacement N-S
PROCESS CONDITION : Dump Test

PEAK NO.	FREQUENCY	AMPLITUDE
1	30.1	150.70
2	58.9	7.05
3	149.1	6.47
4	89.0	4.05
5	2.4	3.35

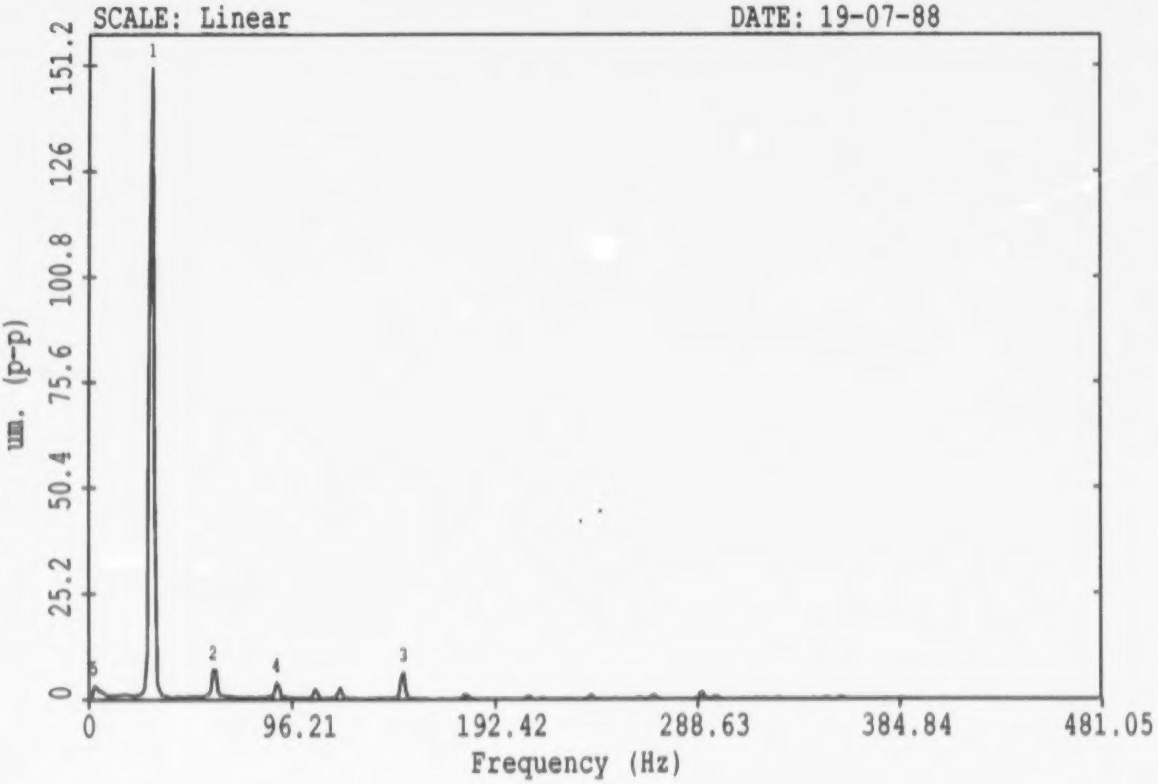


FIGURE 139

PNGS Unit 2 - ECIS Test #3 Moderator Pumpset Vibration

SIGNAL : Expansion Joint #3 Vertical Velocity
PROCESS CONDITION : Dump Test

PEAK NO.	FREQUENCY	AMPLITUDE
1	149.1	1.53
2	4.8	1.22
3	30.1	1.11
4	8.4	0.73
5	16.8	0.70
6	178.0	0.69
7	13.2	0.69
8	138.3	0.69
9	20.4	0.68
10	119.1	0.58

SCALE: Linear

DATE: 19-07-88

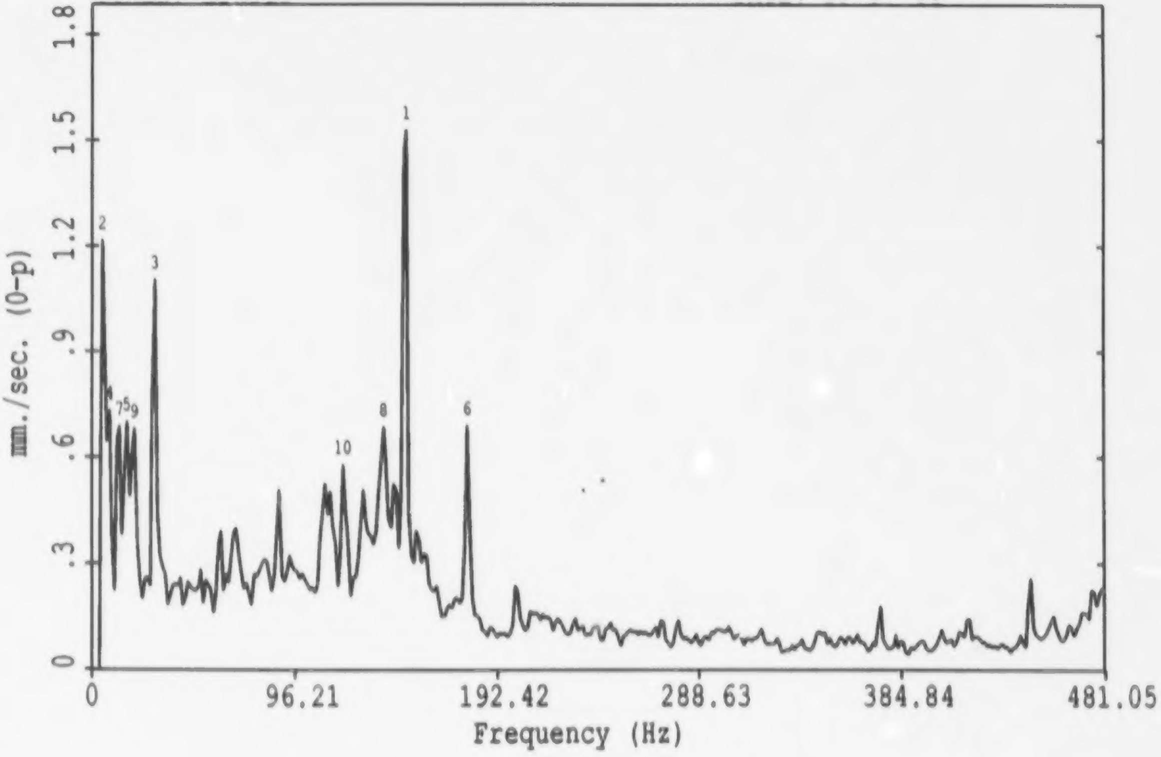


FIGURE 140

PNGS Unit 2 - ECIS Test #3 Moderator Pumpset Vibration

SIGNAL : Expansion Joint #3 Horizontal Velocity
PROCESS CONDITION : Dump Test

PEAK NO.	FREQUENCY	AMPLITUDE
1	149.1	1.77
2	178.0	1.29
3	200.8	1.02
4	258.6	0.94
5	30.1	0.91
6	58.9	0.91
7	119.1	0.85
8	14.4	0.63
9	153.9	0.52
10	263.4	0.51

SCALE: Linear

DATE: 19-07-88

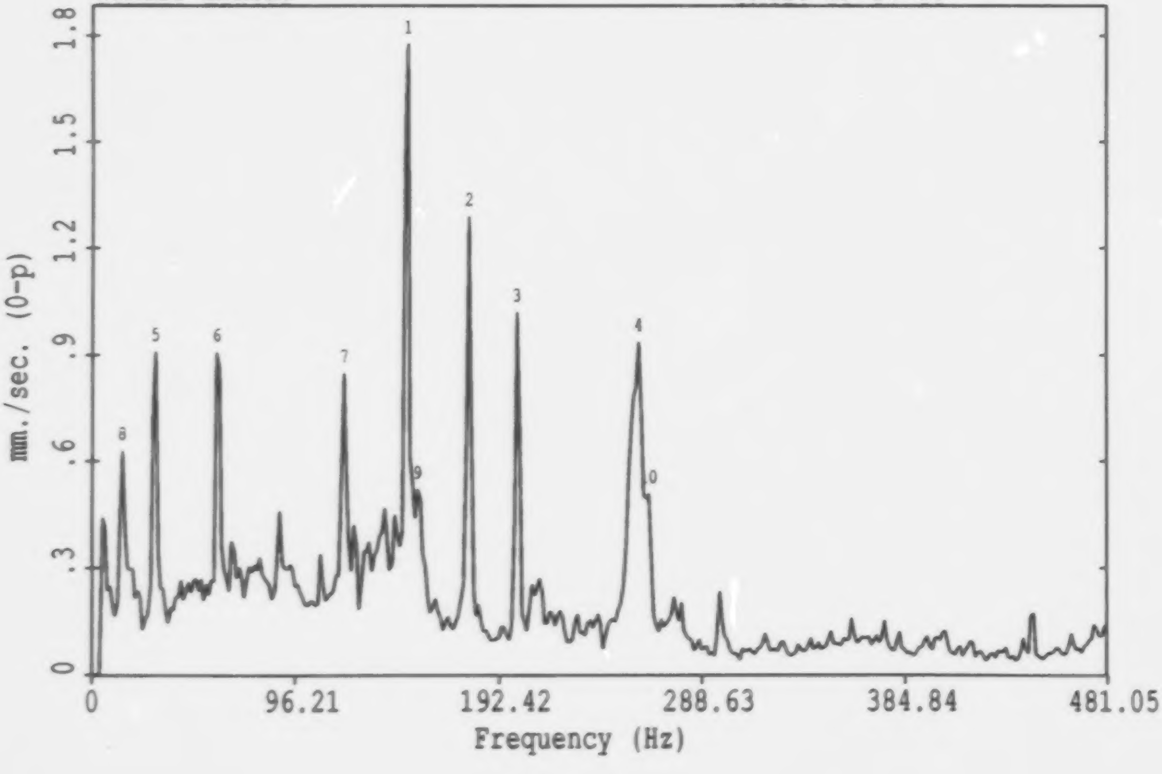


FIGURE 141

PNGS Unit 2 - ECIS Test #3 Moderator Pumpset Vibration

SIGNAL : Expansion Joint #3 Axial Velocity
PROCESS CONDITION : Dump Test

PEAK NO.	FREQUENCY	AMPLITUDE
1	258.6	2.62
2	149.1	2.22
3	16.8	1.26
4	178.0	0.89
5	58.9	0.87
6	119.1	0.85
7	30.1	0.78
8	200.8	0.65
9	20.4	0.50
10	152.7	0.49

SCALE: Linear

DATE: 19-07-88

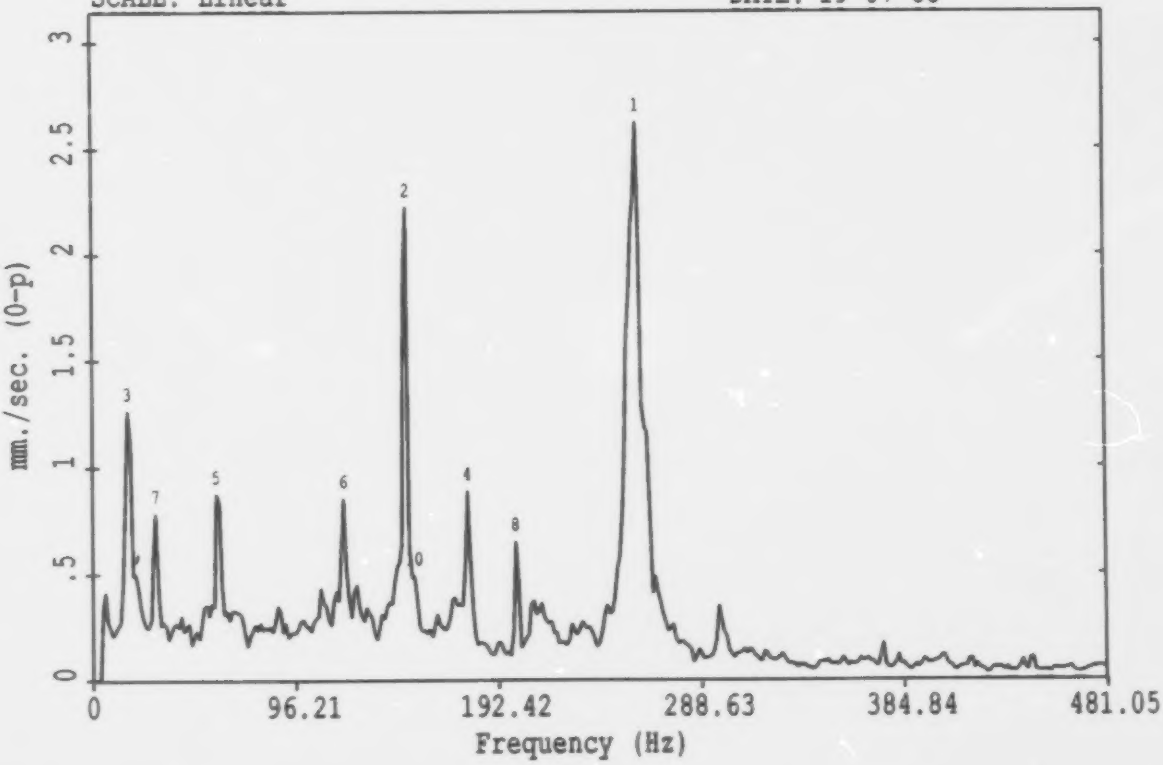


FIGURE 142

PNGS Unit 2 - ECIS Test #3 Moderator Pumpset Vibration

SIGNAL : Expansion Joint #4 Horizontal Velocity
PROCESS CONDITION : Dump Test

PEAK NO.	FREQUENCY	AMPLITUDE
1	18.0	1.92
2	60.1	0.77
3	178.0	0.63
4	30.1	0.56
5	7.2	0.53
6	9.6	0.50
7	297.1	0.42
8	149.1	0.41
9	68.6	0.34
10	119.1	0.34

SCALE: Linear

DATE: 19-07-88

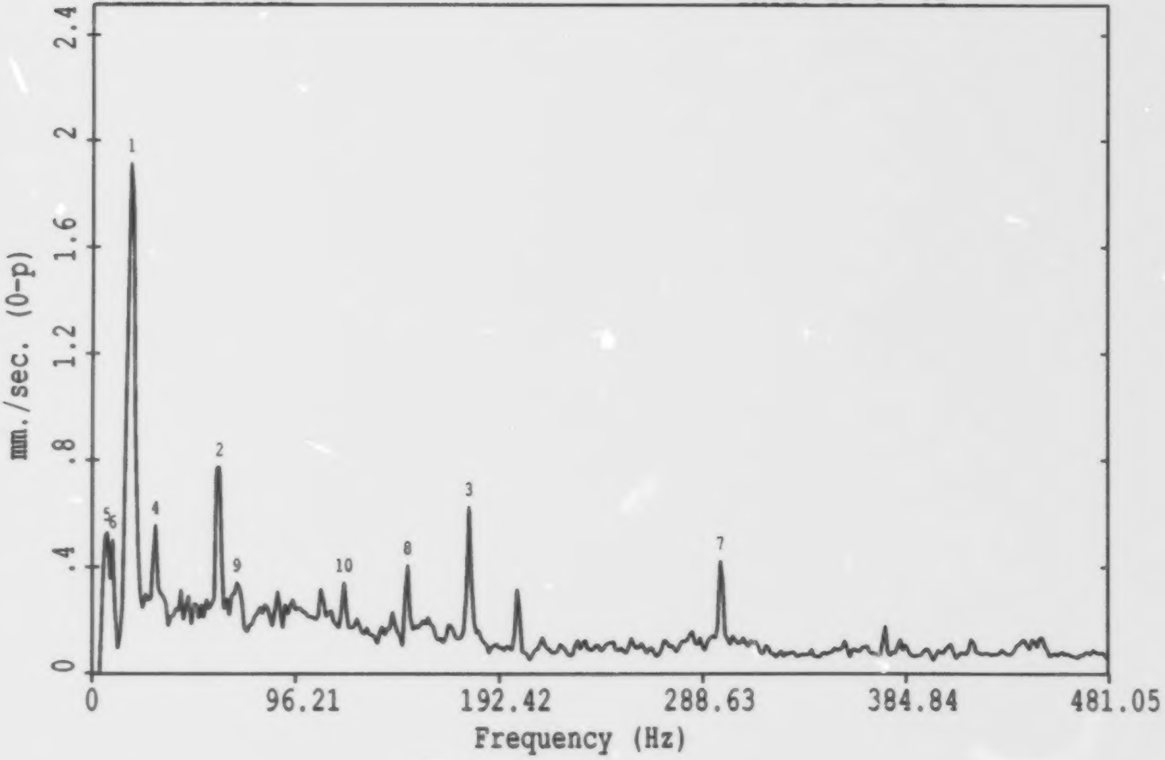


FIGURE 143

PNGS Unit 2 - ECIS Test #3 Moderator Pumpset Vibration

SIGNAL : Expansion Joint #4 Axial Velocity
PROCESS CONDITION : Dump Test

PEAK NO.	FREQUENCY	AMPLITUDE
1	4.8	4.10
2	30.1	2.01
3	14.4	1.48
4	16.8	1.28
5	149.1	1.19
6	20.4	0.98
7	200.8	0.92
8	24.1	0.86
9	169.6	0.80
10	60.1	0.72

SCALE: Linear

DATE: 19-07-88

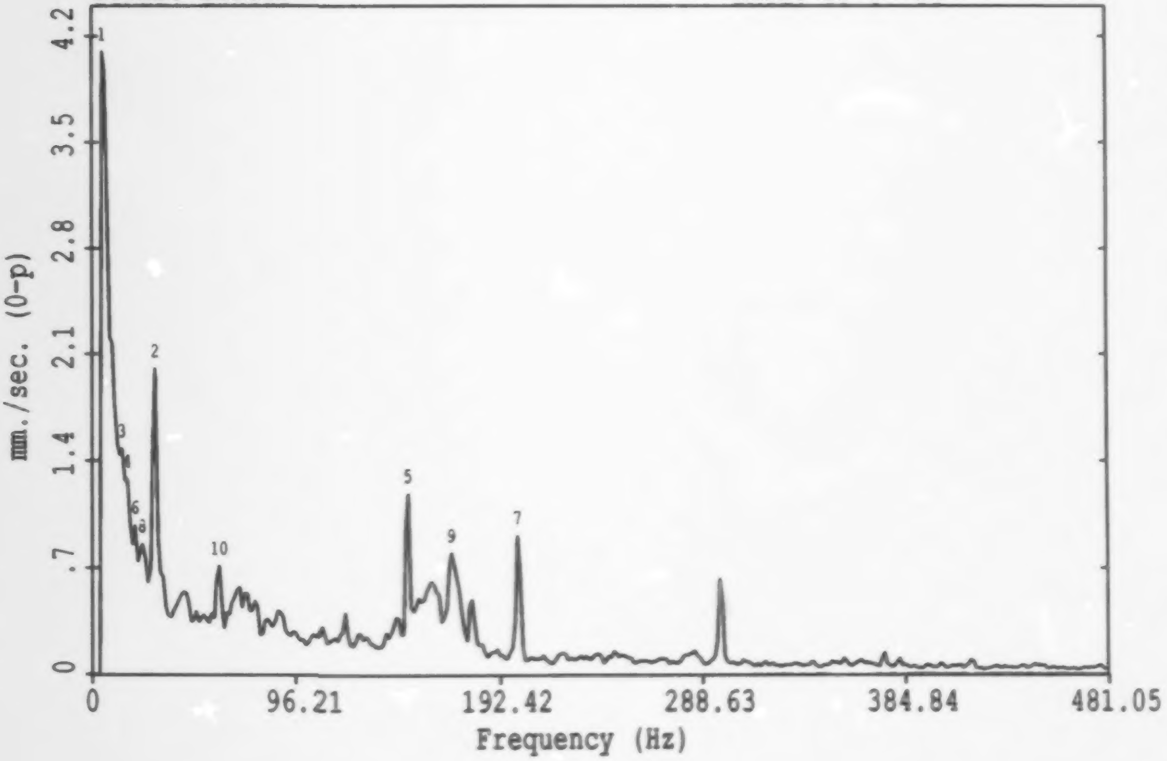


FIGURE 144

PNGS Unit 2 - ECIS Test #3 Moderator Pumpset Vibration

SIGNAL : Pumpset #1 - Motor Casing Vel N-S
PROCESS CONDITION : CIV Closure Test

PEAK NO.	FREQUENCY	AMPLITUDE
1	6.0	14.22
2	149.1	2.94
3	60.1	1.94
4	77.0	1.83
5	30.1	1.67
6	66.1	1.58
7	72.2	1.36
8	40.9	0.84
9	13.2	0.83
10	21.6	0.69

SCALE: Linear DATE: 19-07-88

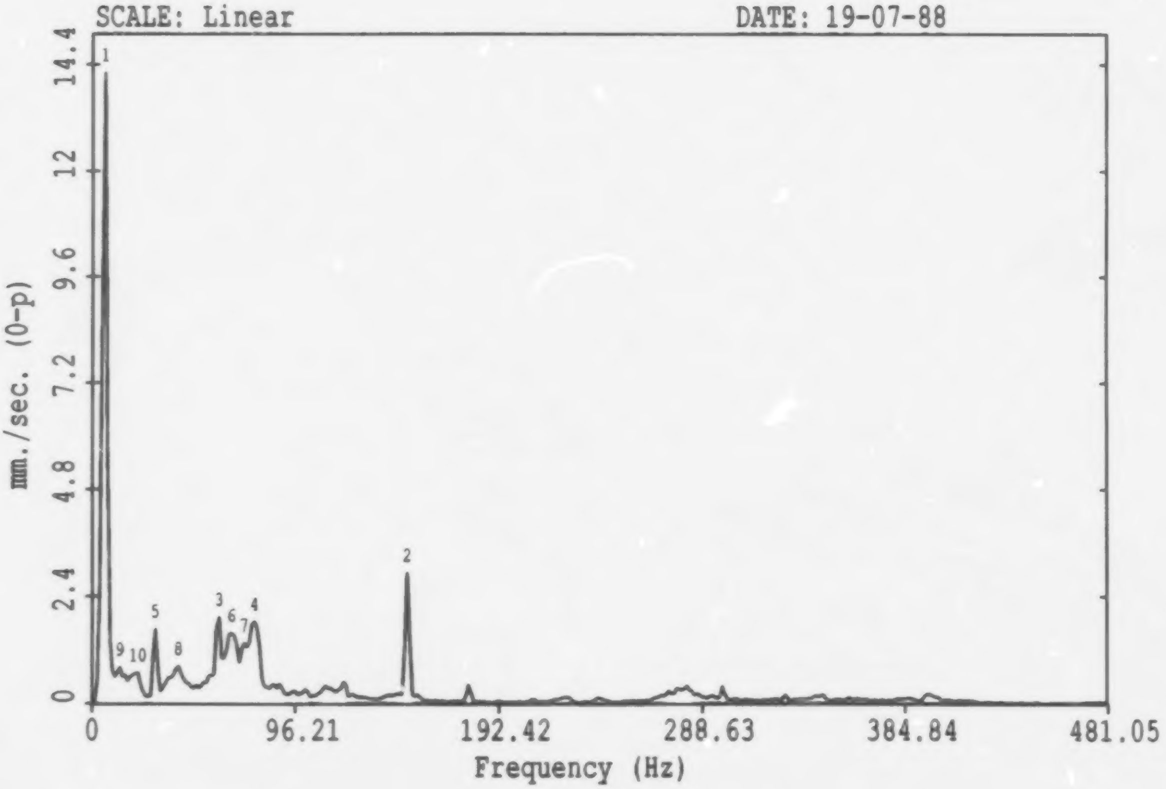


FIGURE 145

PNGS Unit 2 - ECIS Test #3 Moderator Pumpset Vibration

SIGNAL : Pumpset #2 - Motor Casing Vel E-W
PROCESS CONDITION : CIV Closure Test

PEAK NO.	FREQUENCY	AMPLITUDE
1	9.6	6.41
2	6.0	5.16
3	149.1	2.20
4	44.5	1.31
5	119.1	1.21
6	298.3	1.15
7	30.1	1.11
8	73.4	1.10
9	39.7	1.03
10	89.0	1.00

SCALE: Linear

DATE: 19-07-88

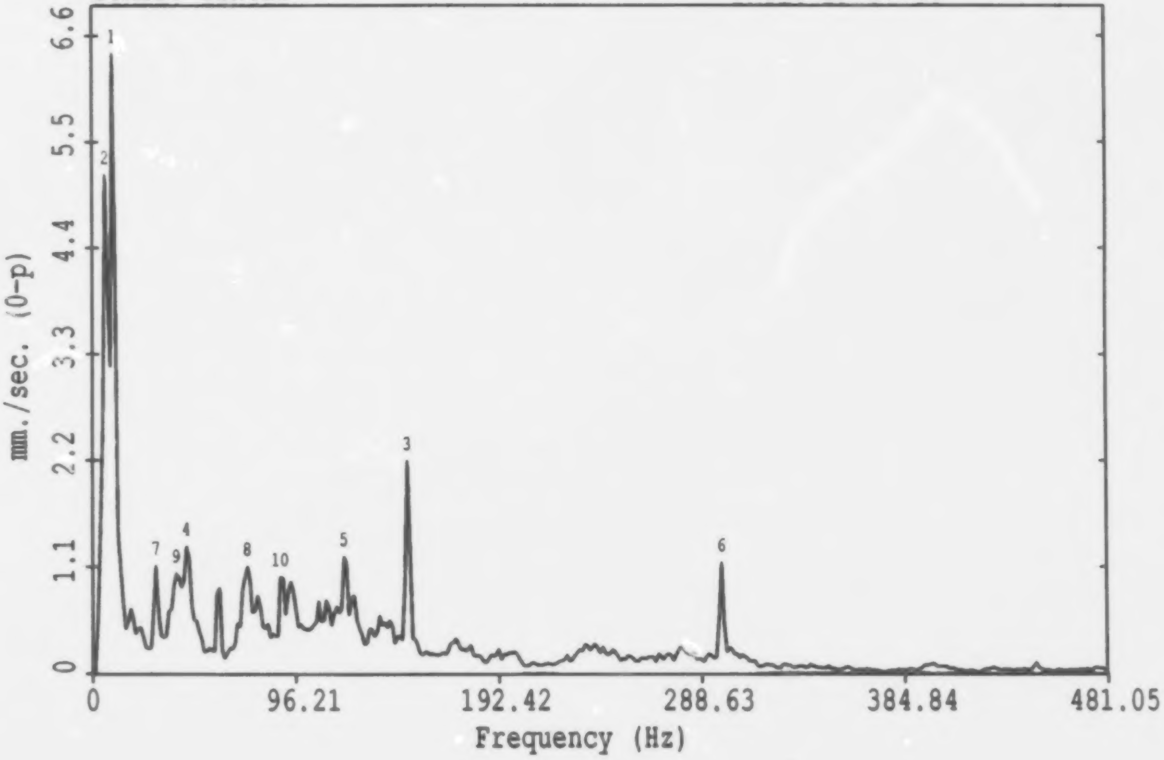


FIGURE 146

PNGS Unit 2 - ECIS Test #3 Moderator Pumpset Vibration

SIGNAL : Pumpset #2 - Motor Casing Vel N-S
PROCESS CONDITION : CIV Closure Test

PEAK NO.	FREQUENCY	AMPLITUDE
1	6.0	17.18
2	30.1	3.61
3	9.6	2.72
4	149.1	1.64
5	72.2	1.28
6	68.6	1.23
7	80.6	1.20
8	298.3	1.13
9	78.2	1.13
10	64.9	1.07

SCALE: Linear DATE: 19-07-88

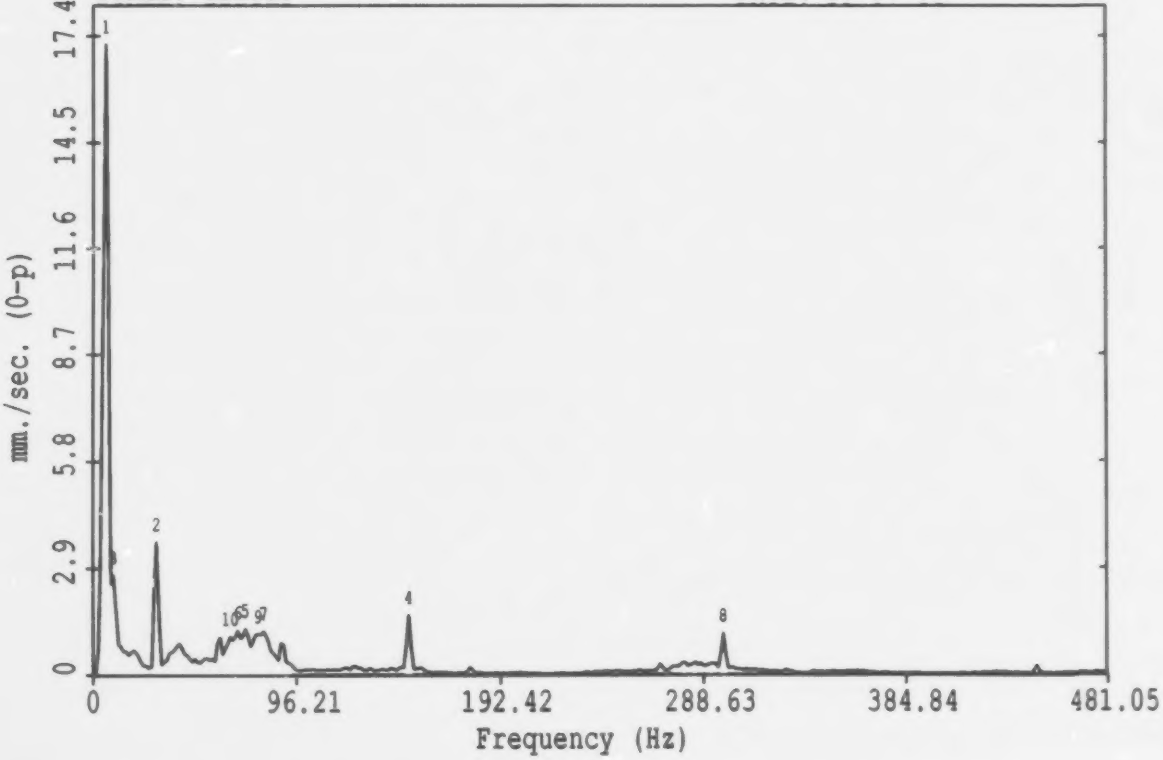


FIGURE 147

PNGS Unit 2 - ECIS Test #3 Moderator Pumpset Vibration

SIGNAL : Pumpset #3 - Motor Casing Velocity N-S
PROCESS CONDITION : CIV Closure Test

PEAK NO.	FREQUENCY	AMPLITUDE
1	6.0	11.10
2	149.1	2.77
3	60.1	1.32
4	71.0	1.27
5	80.6	1.20
6	78.2	1.13
7	13.2	1.10
8	30.1	1.08
9	298.3	0.96
10	40.9	0.83

SCALE: Linear DATE: 19-07-88

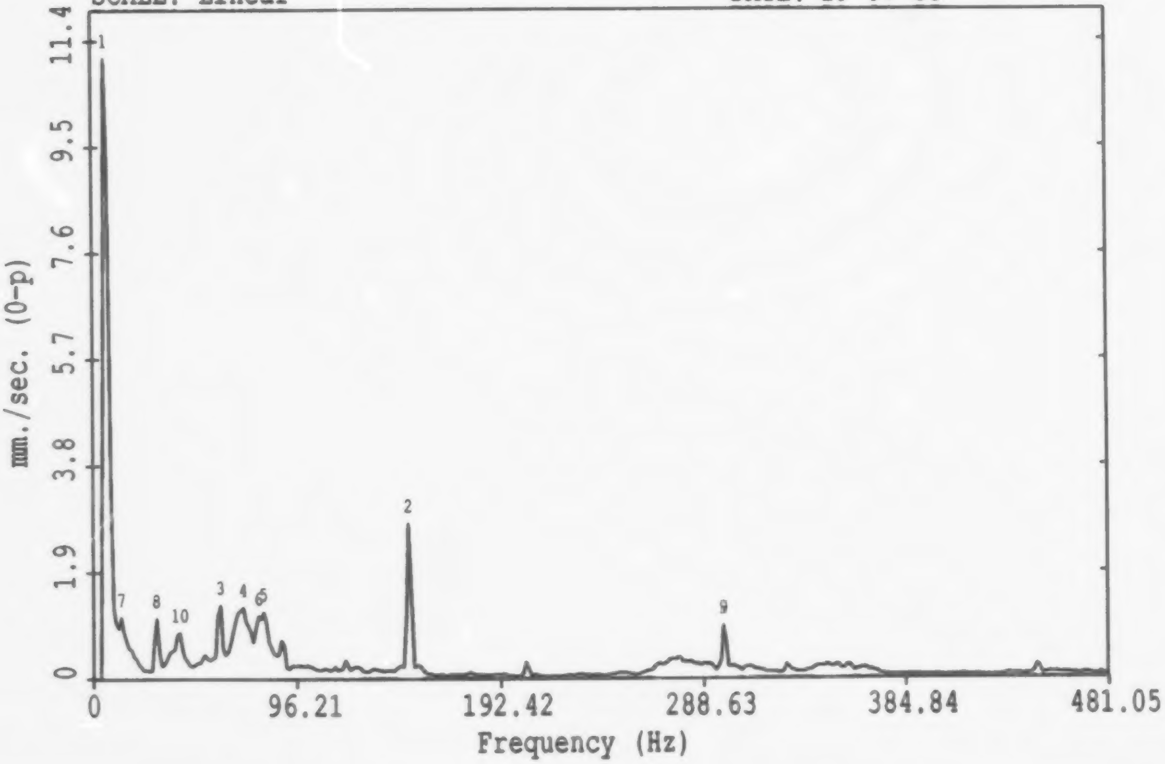


FIGURE 148

PNGS Unit 2 - ECIS Test #3 Moderator Pumpset Vibration

SIGNAL   : Pumpset #4 - Motor Casing Velocity E-W
PROCESS CONDITION : CIV Closure Test

PEAK NO.	FREQUENCY	AMPLITUDE
1	7.2	5.86
2	30.1	1.68
3	15.6	1.68
4	60.1	1.41
5	36.1	0.73
6	62.5	0.72
7	67.3	0.71
8	21.6	0.52
9	149.1	0.44
10	46.9	0.40

SCALE: Linear

DATE: 19-07-88

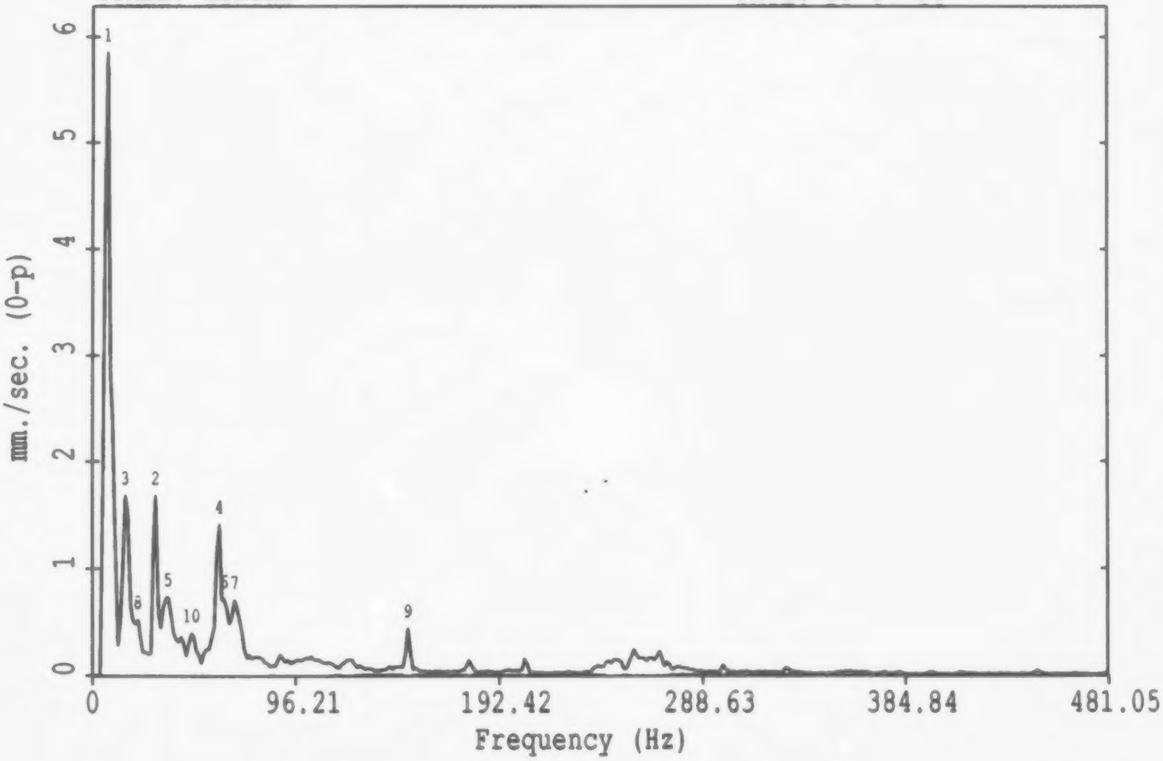


FIGURE 149

PNGS Unit 2 - ECIS Test #3 Moderator Pumpset Vibration

SIGNAL : Pumpset #5 - Motor Casing Vel E-W
PROCESS CONDITION : CIV Closure Test

PEAK NO.	FREQUENCY	AMPLITUDE
1	7.2	4.66
2	19.2	3.12
3	149.1	2.73
4	9.6	2.65
5	30.1	1.87
6	68.6	1.73
7	33.7	1.59
8	64.9	1.47
9	58.9	1.42
10	48.1	1.09

SCALE: Linear

DATE: 19-07-88

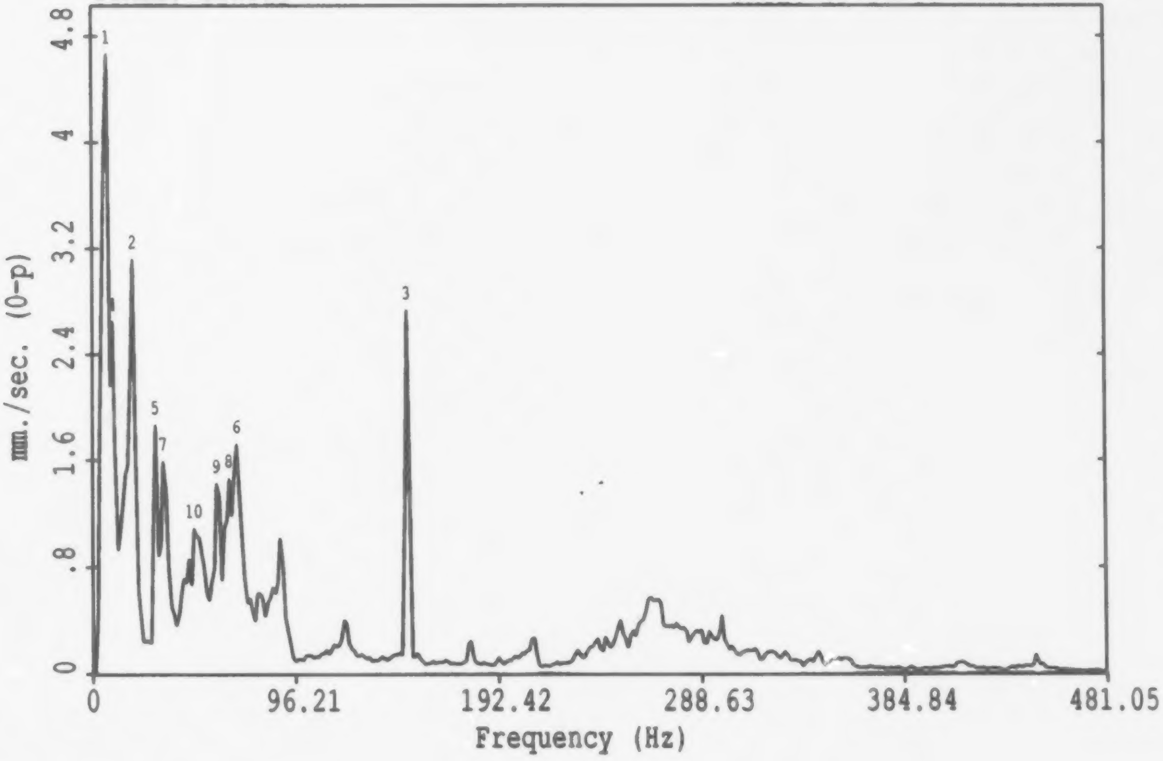


FIGURE 150

PNGS Unit 2 - ECIS Test #3 Moderator Pumpset Vibration

SIGNAL : Pumpset #5 - Motor Casing Vel N-S
PROCESS CONDITION : CIV Closure Test

PEAK NO.	FREQUENCY	AMPLITUDE
1	9.6	4.39
2	4.8	4.12
3	149.1	3.01
4	19.2	1.62
5	45.7	1.33
6	15.6	1.26
7	298.3	1.11
8	30.1	1.07
9	48.1	1.04
10	39.7	0.80

SCALE: Linear DATE: 19-07-88

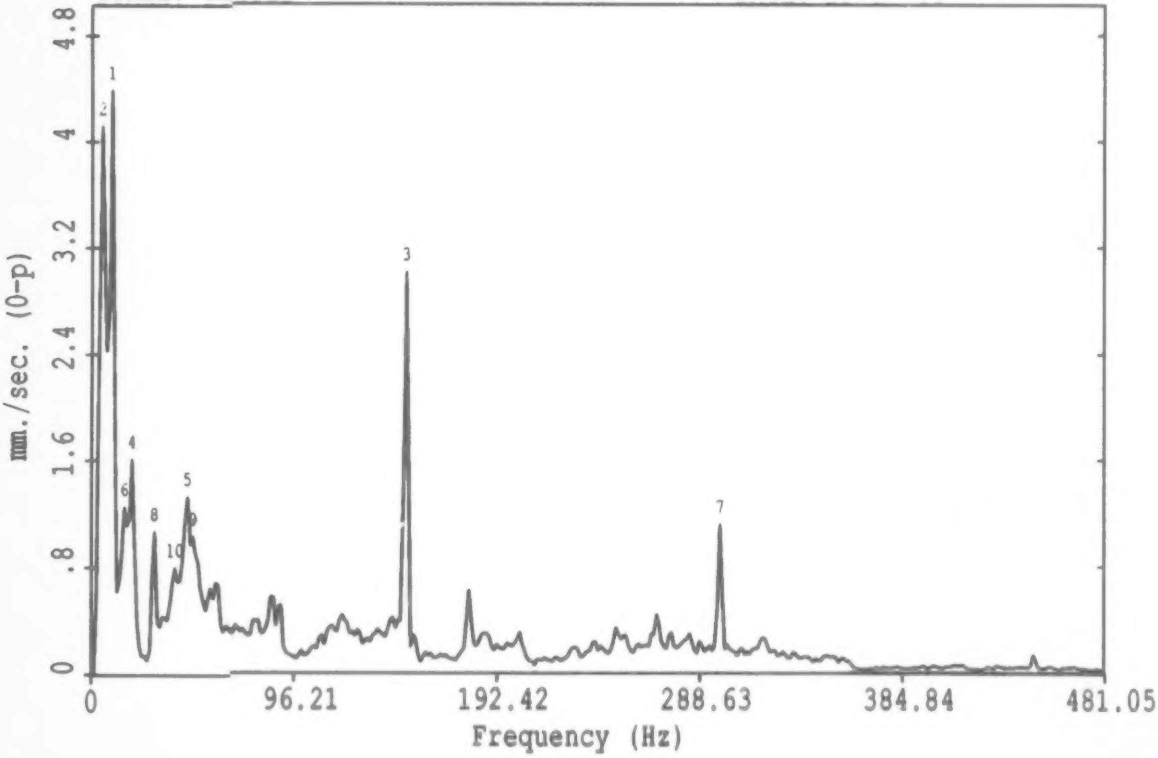


FIGURE 151

PNGS Unit 2 - ECIS Test #3 Moderator Pumpset Vibration

SIGNAL : Pumpset #1 - Pump Shaft Displacement E-W
PROCESS CONDITION : CIV Closure Test

PEAK NO.	FREQUENCY	AMPLITUDE
1	30.1	76.35
2	149.1	58.48
3	60.1	27.24
4	89.0	16.93
5	119.1	7.88
6	2.4	7.76
7	22.9	7.34
8	14.4	7.23
9	25.3	7.16
10	36.1	6.95

SCALE: Linear. DATE: 19-07-88

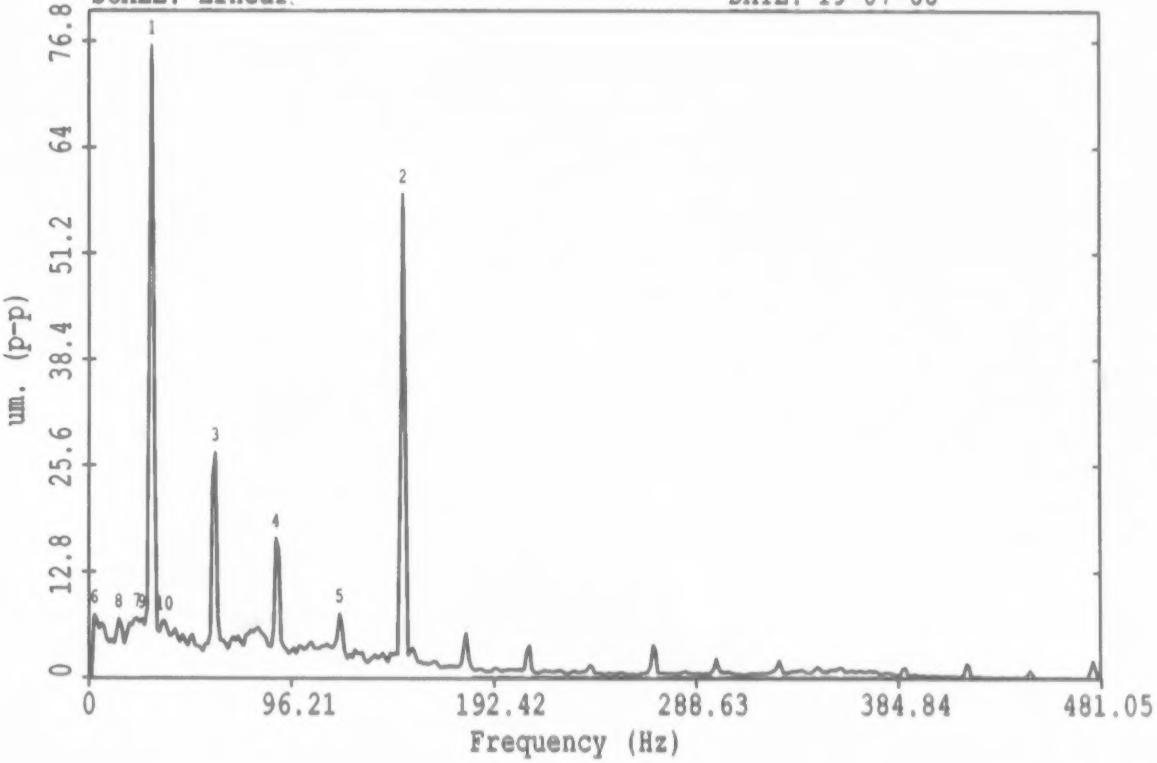


FIGURE 152

PNGS Unit 2 - ECIS Test #3 Moderator Pumpset Vibration

SIGNAL : Pumpset #1 - Pump Shaft Displacement N-S
PROCESS CONDITION : CIV Closure Test

PEAK NO.	FREQUENCY	AMPLITUDE
1	30.1	86.69
2	149.1	60.32
3	6.0	19.60
4	60.1	18.59
5	89.0	15.22
6	75.8	8.91
7	78.2	8.90
8	72.2	8.61
9	68.6	7.76
10	19.2	6.23

SCALE: Linear DATE: 19-07-88

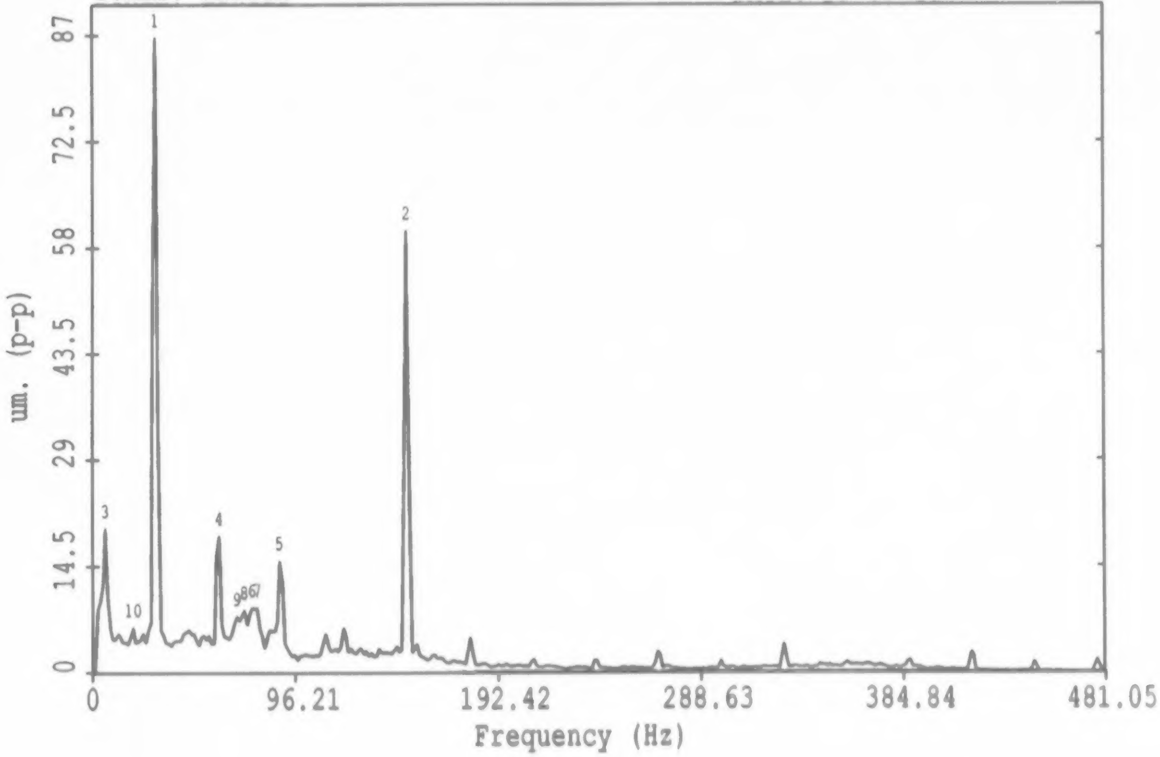


FIGURE 153

PNGS Unit 2 - ECIS Test #3 Moderator Pumpset Vibration

SIGNAL : Pumpset #2 - Pump Shaft Displacement E-W
PROCESS CONDITION : CIV Closure Test

PEAK NO.	FREQUENCY	AMPLITUDE
1	30.1	125.40
2	149.1	35.05
3	60.1	19.23
4	179.2	17.87
5	89.0	14.35
6	119.1	11.22
7	2.4	6.82
8	6.0	6.22
9	92.6	5.04
10	72.2	4.99

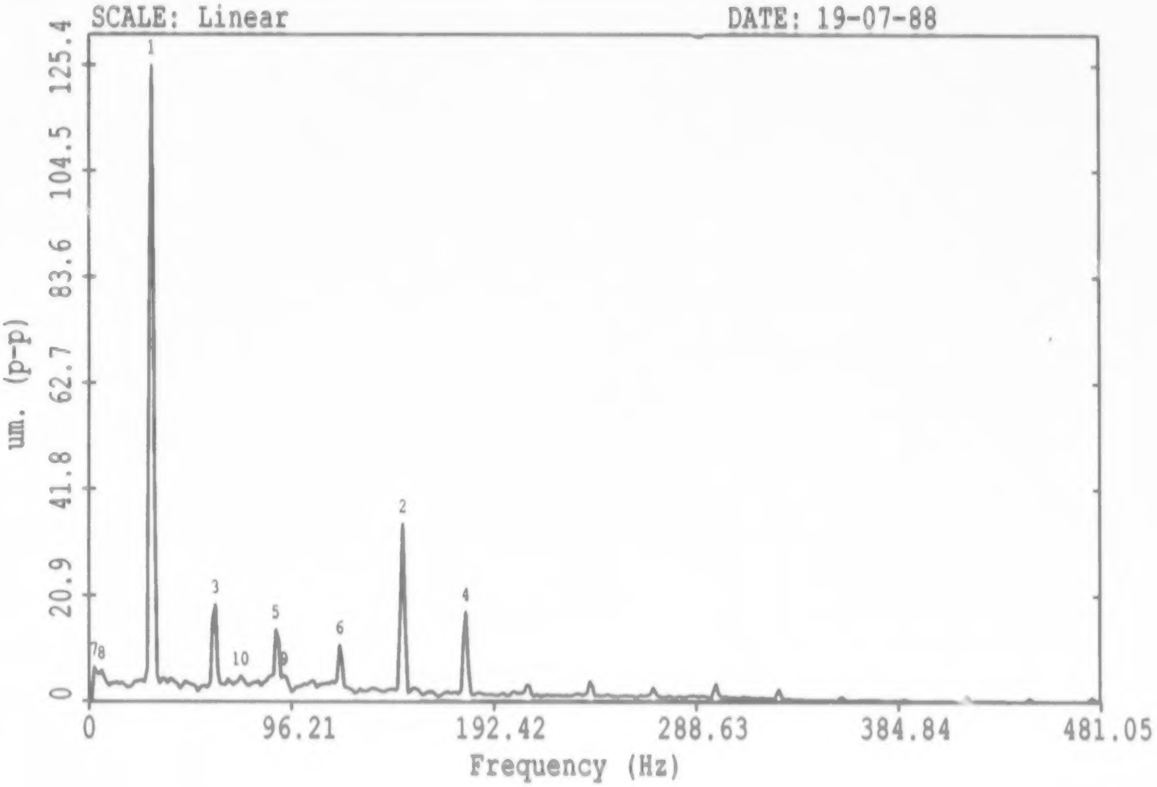


FIGURE 154

PNGS Unit 2 - ECIS Test #3 Moderator Pumpset Vibration

SIGNAL : Pumpset #2 - Pump Shaft Displacement N-S
PROCESS CONDITION : CIV Closure Test

PEAK NO.	FREQUENCY	AMPLITUDE
1	30.1	145.80
2	60.1	43.75
3	149.1	14.07
4	2.4	10.38
5	6.0	9.35
6	89.0	8.47
7	179.2	5.89
8	13.2	5.64
9	10.8	5.35
10	15.6	5.31

SCALE: Linear

DATE: 19-07-88

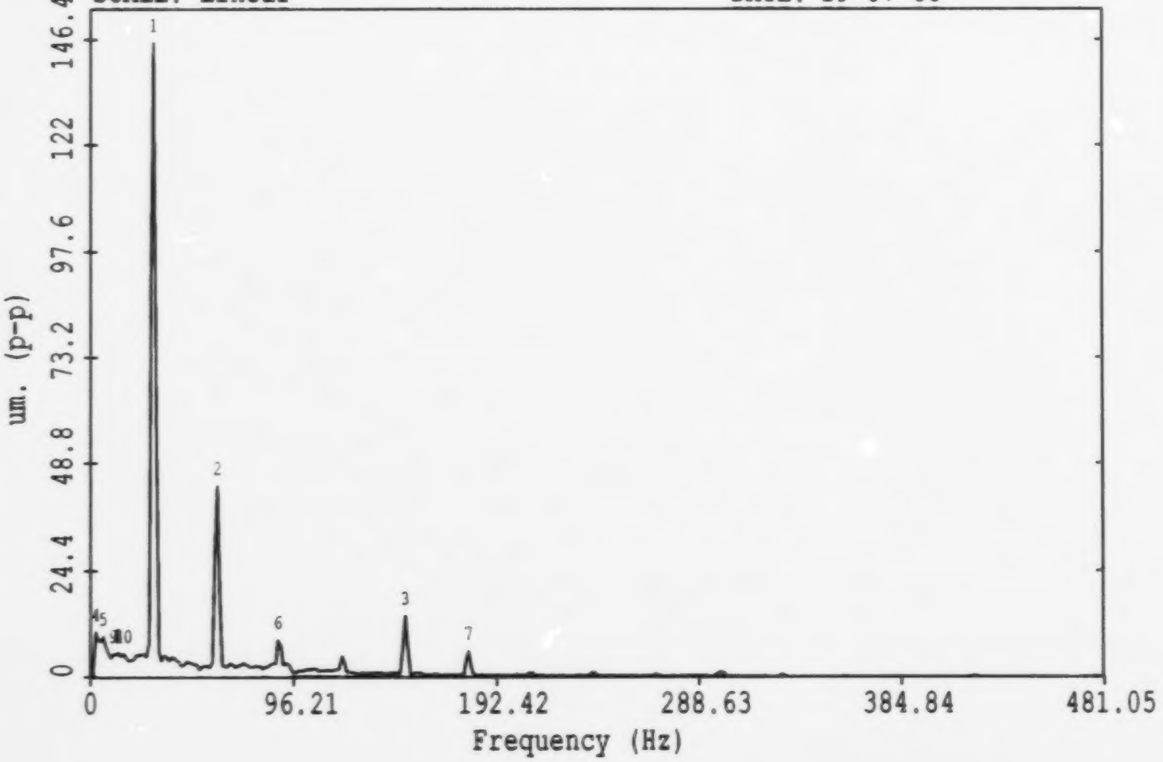


FIGURE 155

PNGS Unit 2 - ECIS Test #3 Moderator Pumpset Vibration

SIGNAL : Pumpset #3 - Pump Shaft Displacement E-W
PROCESS CONDITION : CIV Closure Test

PEAK NO.	FREQUENCY	AMPLITUDE
1	30.1	154.90
2	149.1	57.78
3	6.0	15.35
4	60.1	13.60
5	89.0	10.51
6	119.1	7.19
7	78.2	6.74
8	73.4	6.37
9	68.6	6.22
10	86.6	6.19

SCALE: Linear

DATE: 19-07-88

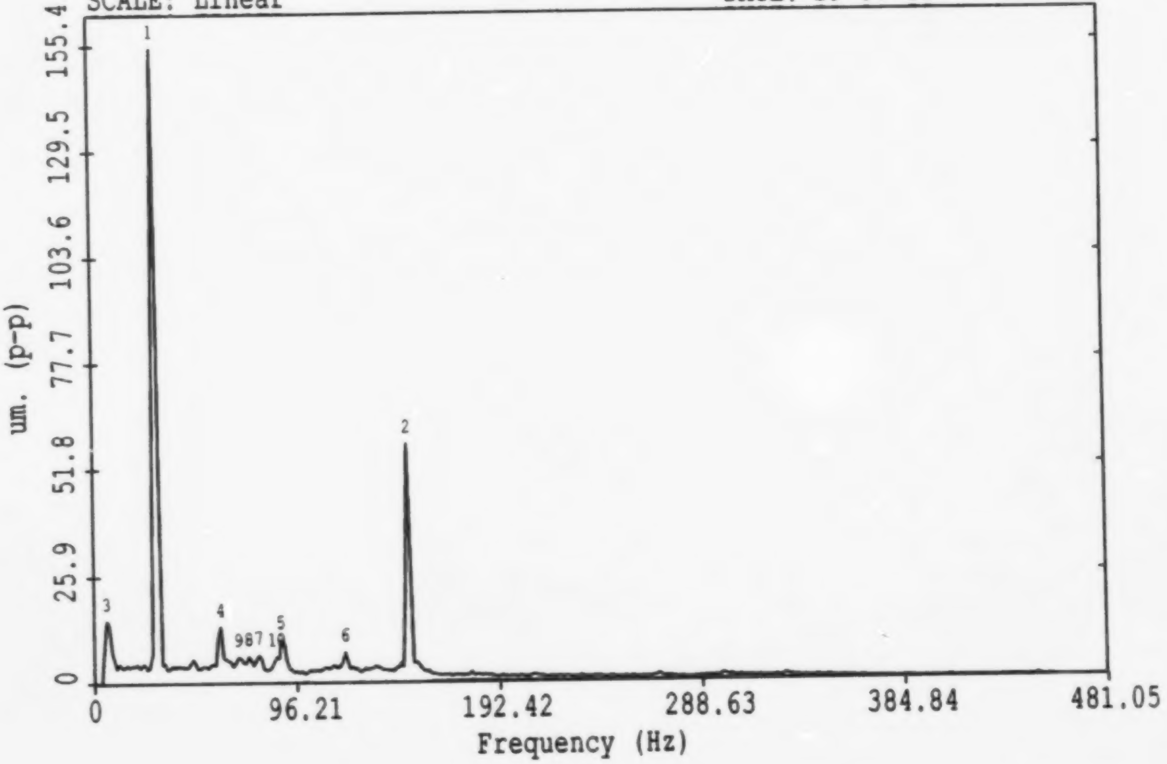


FIGURE 156

PNGS Unit 2 - ECIS Test #3 Moderator Pumpset Vibration

SIGNAL : Pumpset #4 - Pump Shaft Displacement E-W
PROCESS CONDITION : CIV Closure Test

PEAK NO.	FREQUENCY	AMPLITUDE
1	9.6	8.20
2	60.1	4.95
3	6.0	4.89
4	67.3	4.47
5	15.6	3.62
6	149.1	3.40
7	62.5	3.38
8	19.2	3.25
9	30.1	2.83
10	83.0	2.03

SCALE: Linear

DATE: 19-07-88

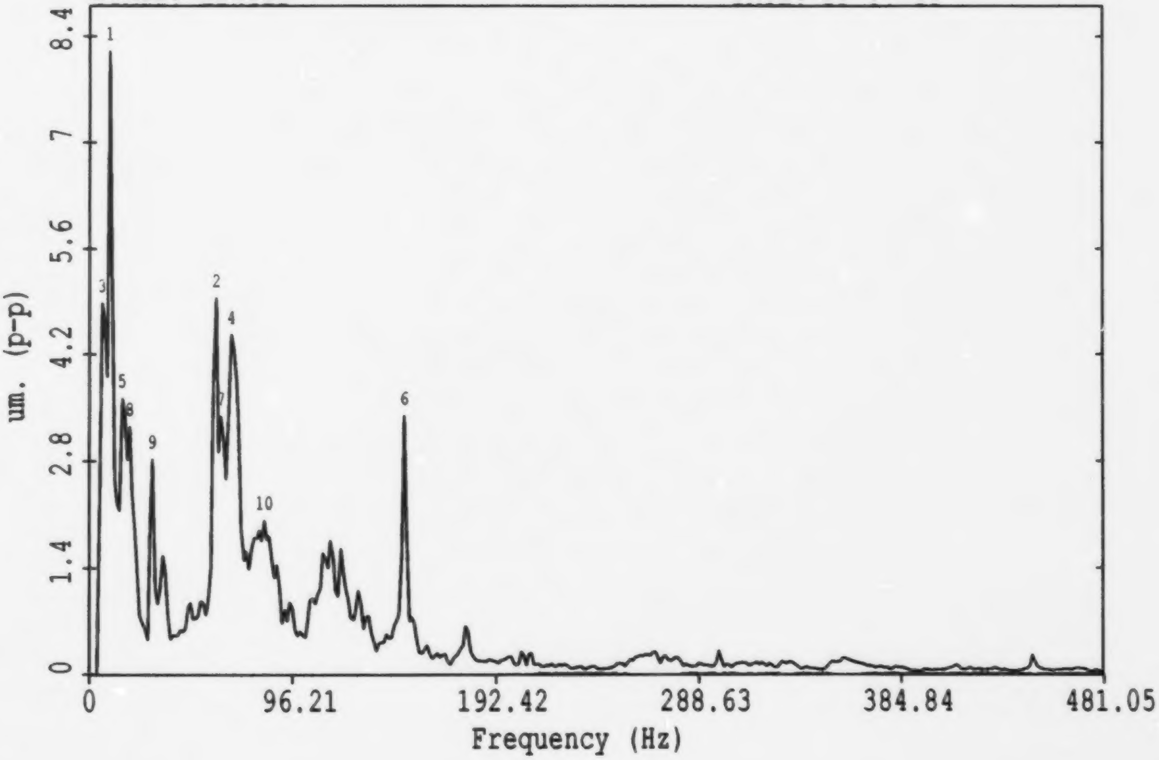


FIGURE 157

PNGS Unit 2 - ECIS Test #3 Moderator Pumpset Vibration

SIGNAL : Pumpset #5 - Pump Shaft Displacement E-W
PROCESS CONDITION : CIV Closure Test

PEAK NO.	FREQUENCY	AMPLITUDE
1	149.1	107.60
2	30.1	98.26
3	119.1	14.33
4	89.0	10.01
5	179.2	9.46
6	2.4	8.94
7	114.3	8.19
8	64.9	7.77
9	86.6	7.41
10	43.3	7.32

SCALE: Linear

DATE: 19-07-88

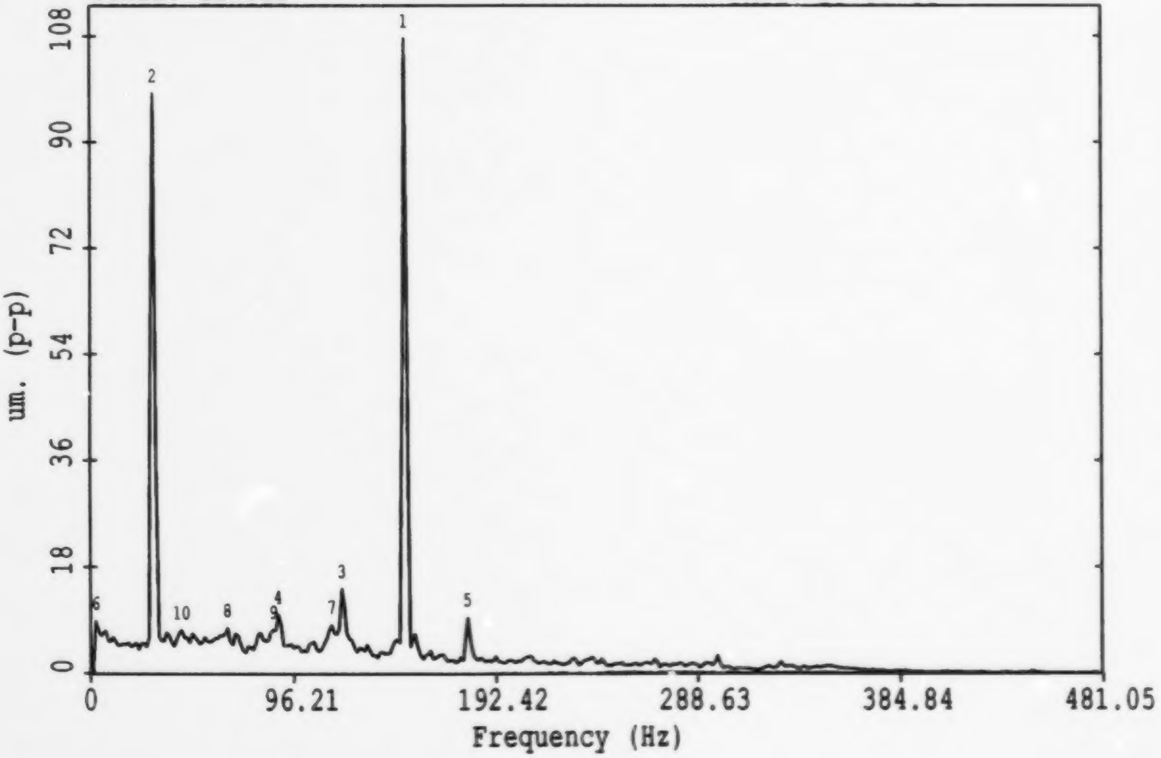


FIGURE 158

PNGS Unit 2 - ECIS Test #3 Moderator Pumpset Vibration

SIGNAL : Pumpset #5 - Pump Shaft Displacement N-S
PROCESS CONDITION : CIV Closure Test

PEAK NO.	FREQUENCY	AMPLITUDE
1	30.1	96.45
2	149.1	50.68
3	119.1	10.34
4	89.0	9.19
5	114.3	7.66
6	58.9	6.30
7	7.2	6.27
8	68.6	6.16
9	179.2	6.08
10	4.8	5.82

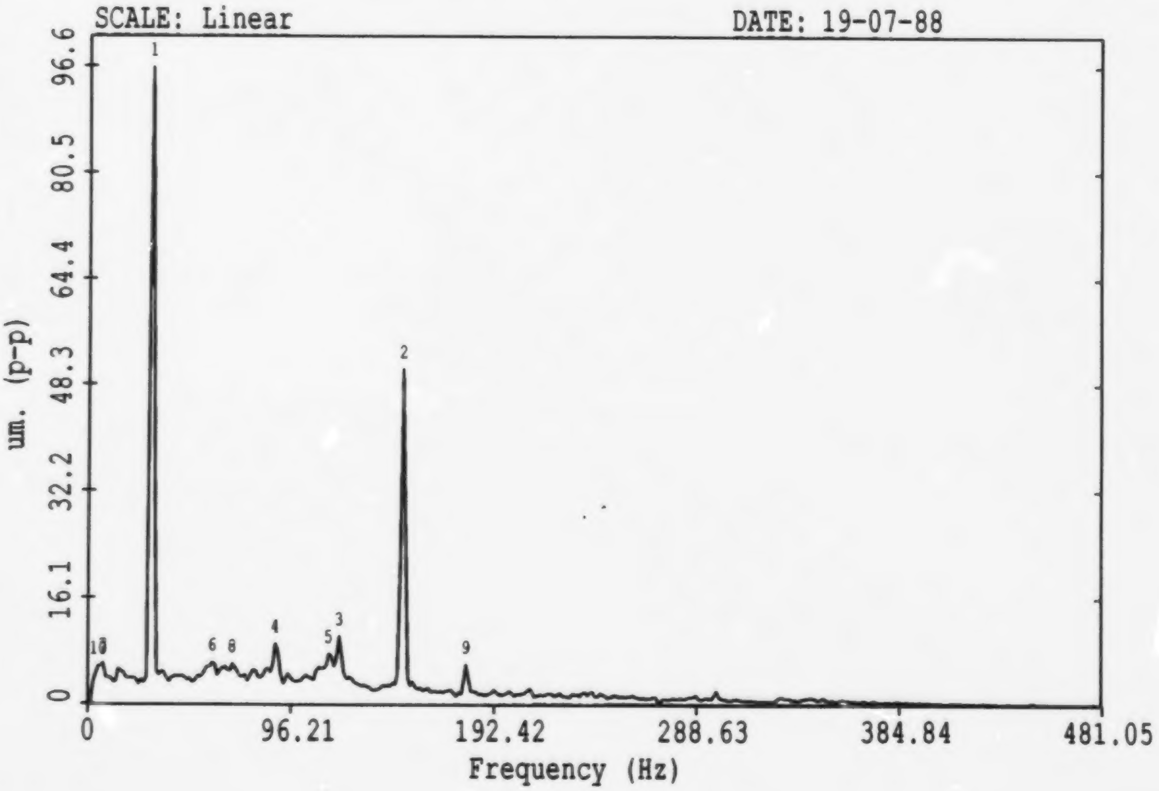


FIGURE 159

PNGS Unit 2 - ECIS Test #3 Moderator Pumpset Vibration

SIGNAL : Expansion Joint #3 Vertical Velocity
PROCESS CONDITION : CIV Closure Test

PEAK NO.	FREQUENCY	AMPLITUDE
1	4.8	12.81
2	149.1	9.49
3	13.2	3.18
4	60.1	2.75
5	119.1	2.59
6	19.2	2.58
7	477.4	2.01
8	473.8	2.00
9	447.4	1.78
10	123.9	1.76

SCALE: Linear DATE: 19-07-88

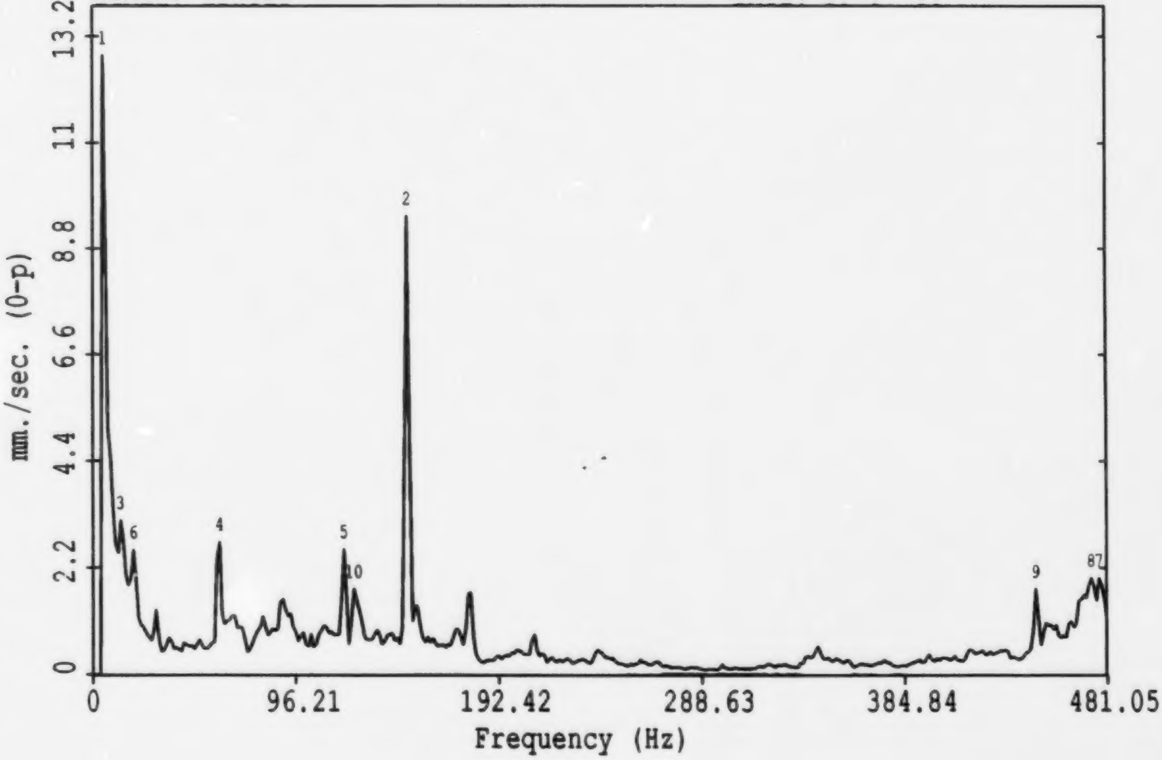


FIGURE 160

PNGS Unit 2 - ECIS Test #3 Moderator Pumpset Vibration

SIGNAL : Expansion Joint #3 Horizontal Velocity
PROCESS CONDITION : CIV Closure Test

PEAK NO.	FREQUENCY	AMPLITUDE
1	4.8	8.80
2	149.1	7.38
3	60.1	4.88
4	119.1	4.04
5	179.2	2.99
6	10.8	2.67
7	30.1	2.63
8	14.4	2.46
9	123.9	2.35
10	80.6	1.89

SCALE: Linear

DATE: 19-07-88

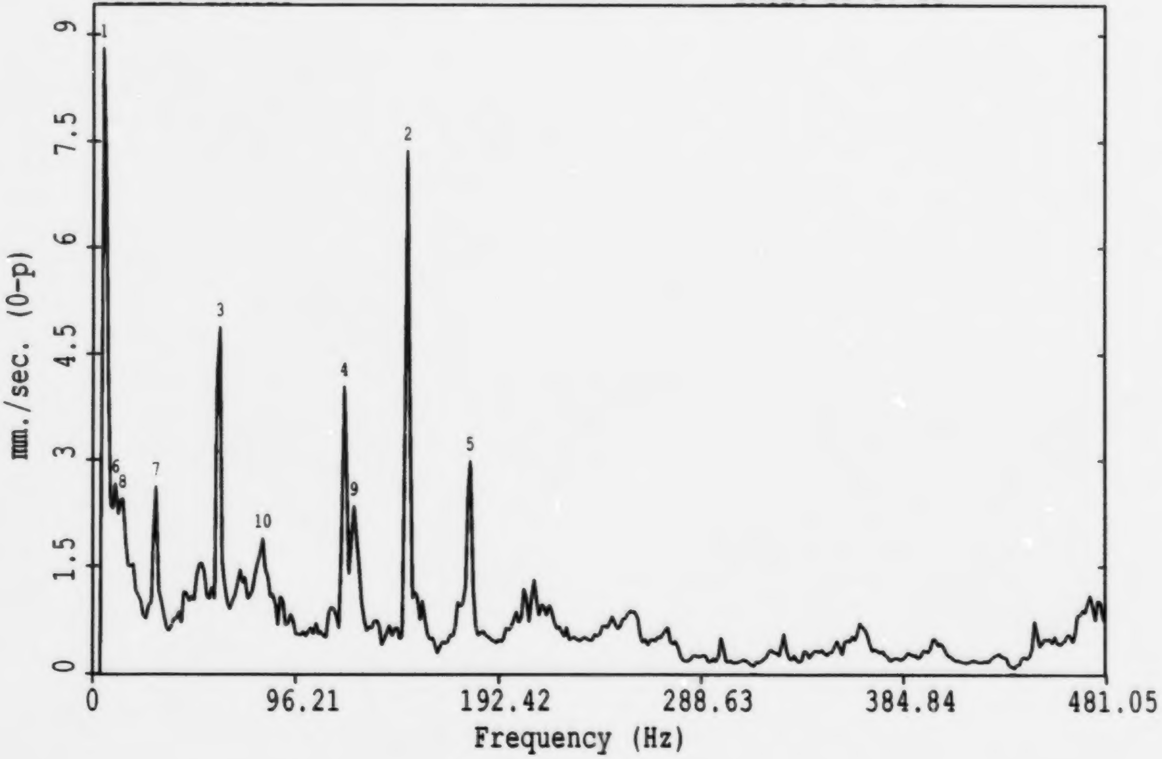


FIGURE 161

PNGS Unit 2 - ECIS Test #3 Moderator Pumpset Vibration

SIGNAL : Expansion Joint #3 Axial Velocity
PROCESS CONDITION : CIV Closure Test

PEAK NO.	FREQUENCY	AMPLITUDE
1	149.1	9.15
2	6.0	6.95
3	60.1	4.47
4	179.2	3.38
5	18.0	3.04
6	13.2	3.00
7	209.3	2.34
8	173.2	2.29
9	216.5	2.21
10	255.0	2.07

SCALE: Linear

DATE: 19-07-88

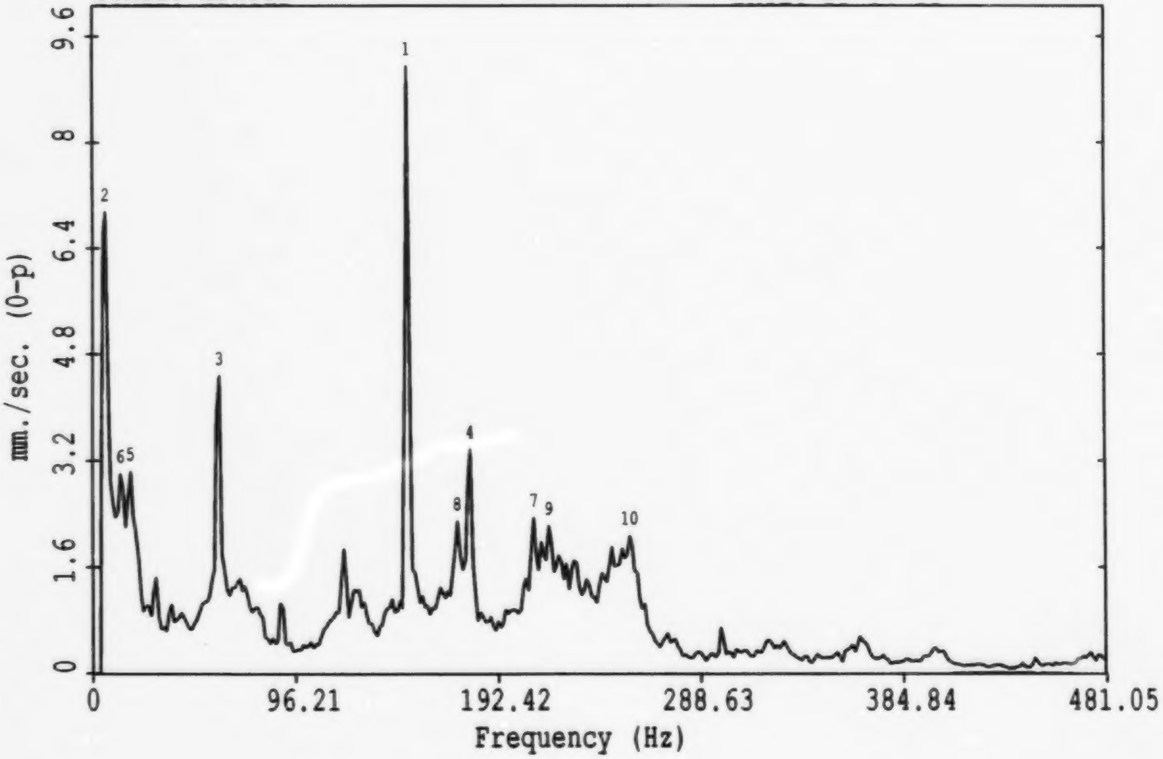


FIGURE 162

PNGS Unit 2 - ECIS Test #3 Moderator Pumpset Vibration

SIGNAL : Expansion Joint #4 Horizontal Velocity
PROCESS CONDITION : CIV Closure Test

PEAK NO.	FREQUENCY	AMPLITUDE
1	19.2	7.25
2	6.0	2.59
3	9.6	2.17
4	60.1	1.98
5	30.1	1.55
6	149.1	1.55
7	67.3	1.45
8	447.4	1.26
9	298.3	1.12
10	46.9	1.11

SCALE: Linear

DATE: 19-07-88

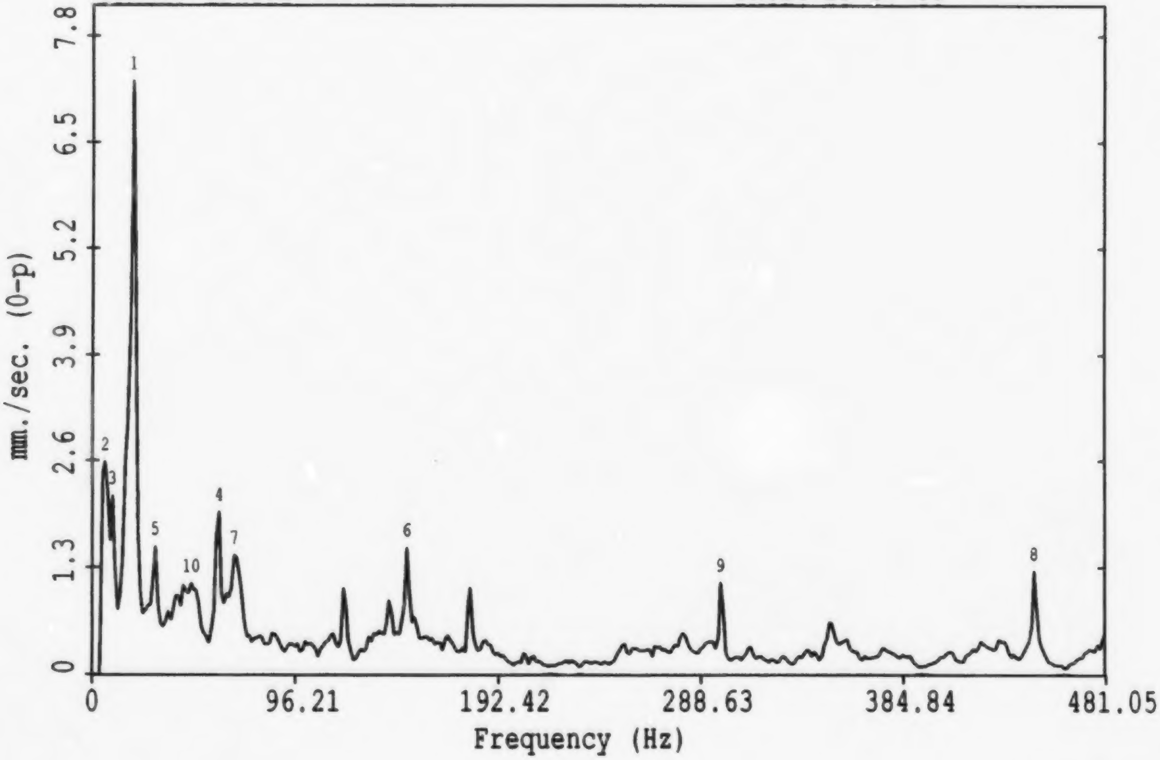


FIGURE 163

PNGS Unit 2 - ECIS Test #3 Moderator Pumpset Vibration

SIGNAL : Expansion Joint #4 Axial Velocity
PROCESS CONDITION : CIV Closure Test

PEAK NO.	FREQUENCY	AMPLITUDE
1	4.8	37.59
2	14.4	10.21
3	19.2	9.55
4	22.9	8.32
5	26.5	6.86
6	30.1	6.78
7	67.3	5.85
8	38.5	5.81
9	34.9	5.80
10	60.1	5.15

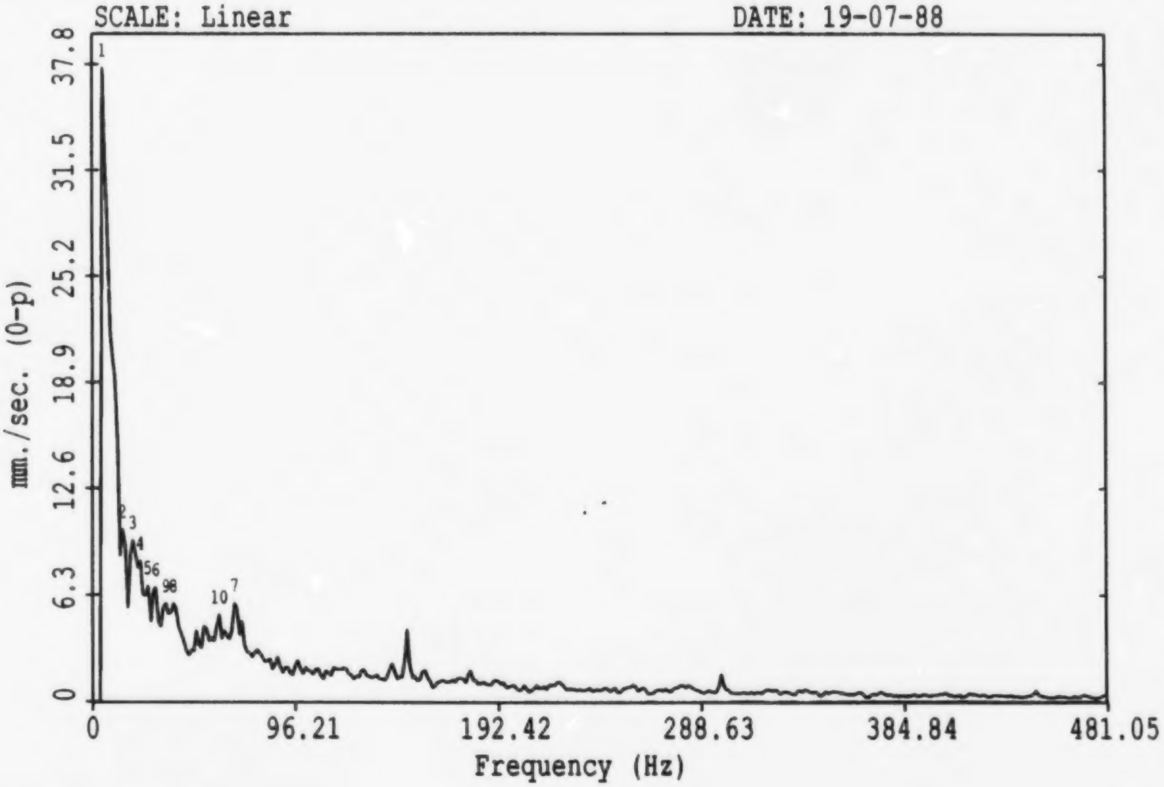


FIGURE 164

APPENDIX A

CALANDRIA DUMP AND CIV CLOSURE TESTS - PLOTS OF PROCESS CONDITIONS

FIGURE 1

PICKERING NGS 'A' UNIT 2 - ECIS TEST NO. 1 (04 JULY 1988)

MODERATOR GROSS FLOW, DUMP PORT LEVEL, AND PUMPSET P3 MOTOR CURRENT

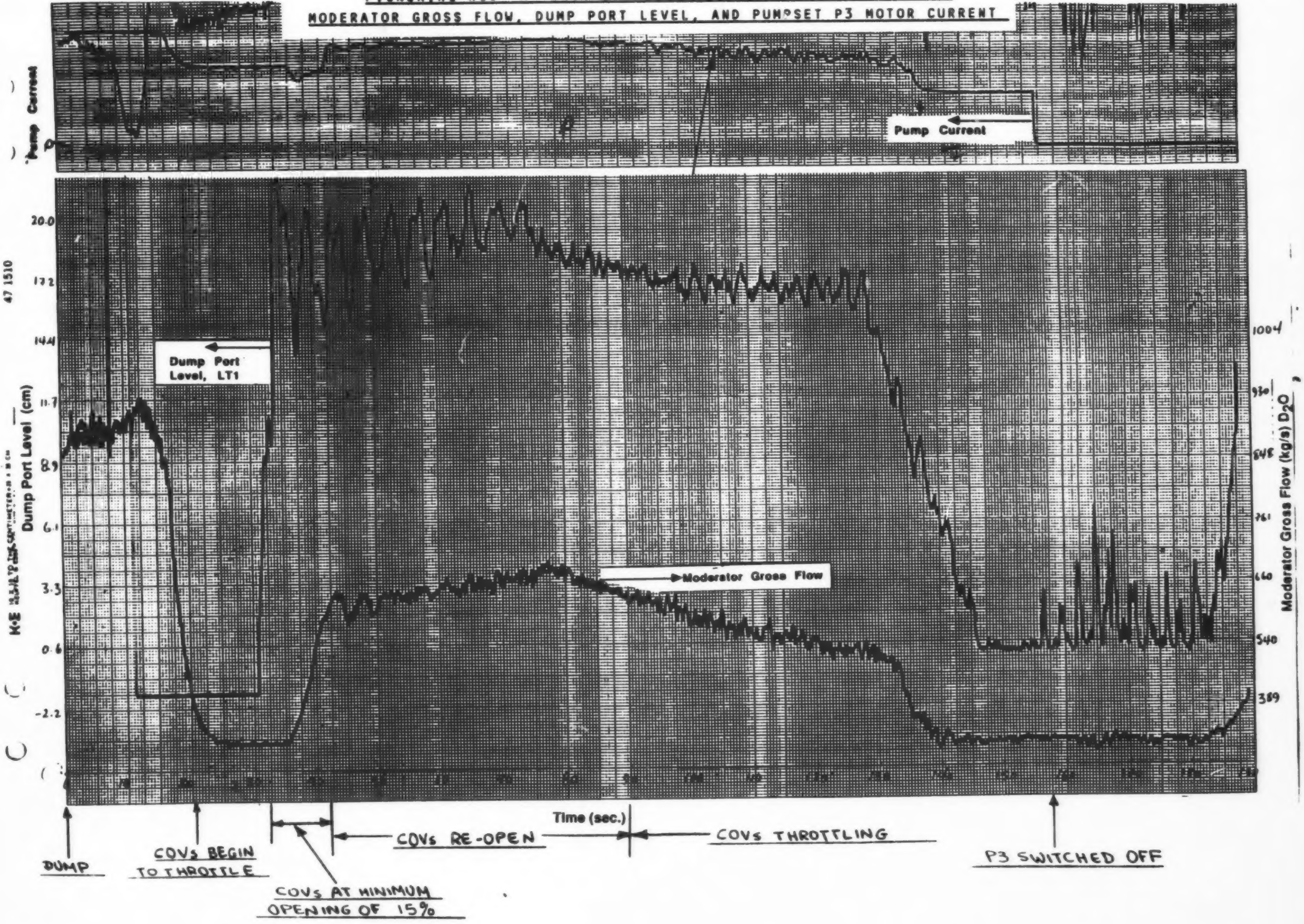


FIGURE 2

PICKERING NGS 'A' UNIT 2 - ECIS TEST NO. 1 (04 JULY 1988)

PUMPSET P3 SUCTION PRESSURE AND DISCHARGE PRESSURE

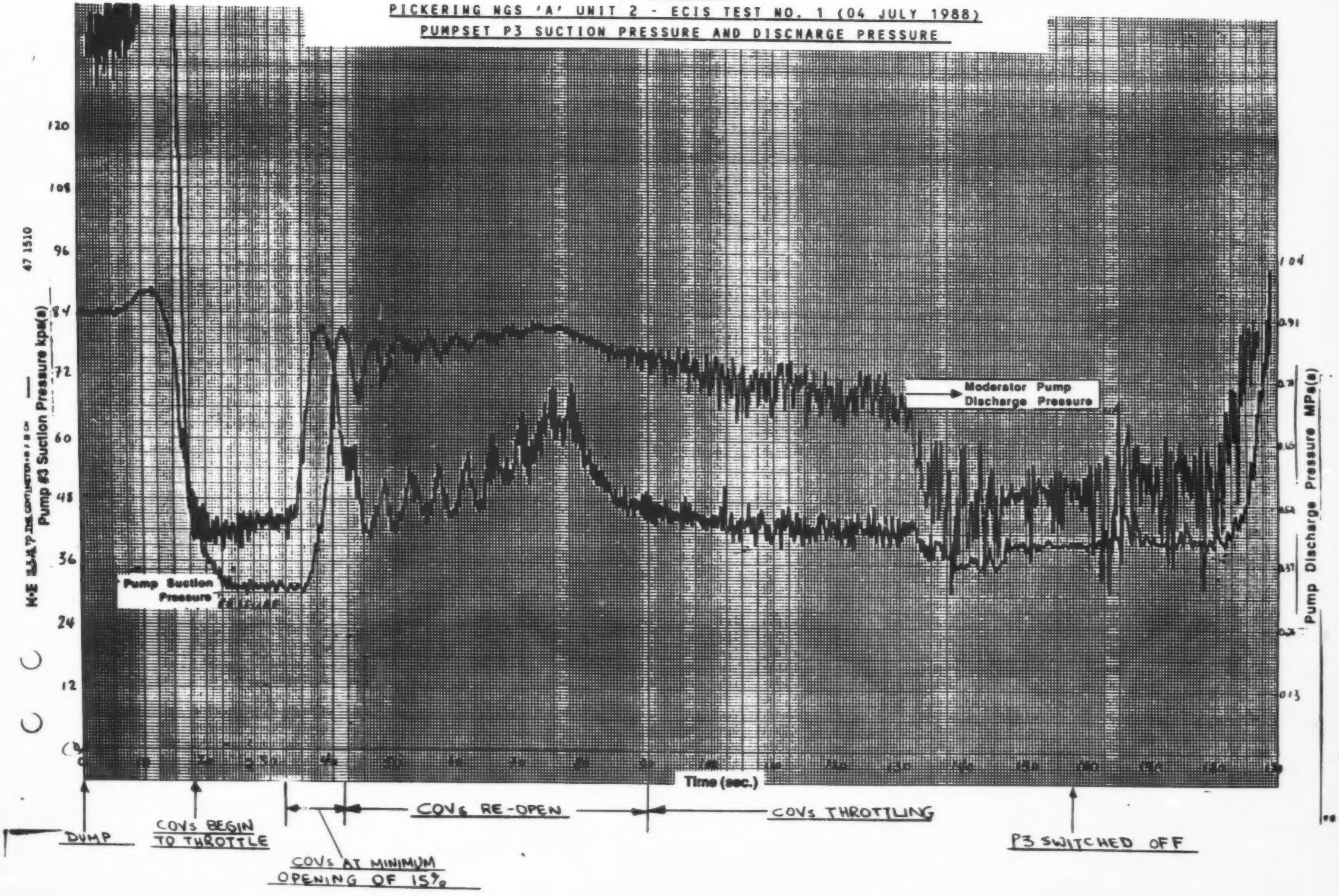


FIGURE 3

PICKERING NGS 'A' UNIT 2 - ECIS TEST NO. 2 (18 JULY 1988)

MODERATOR GROSS FLOW AND DUMP PORT LEVEL

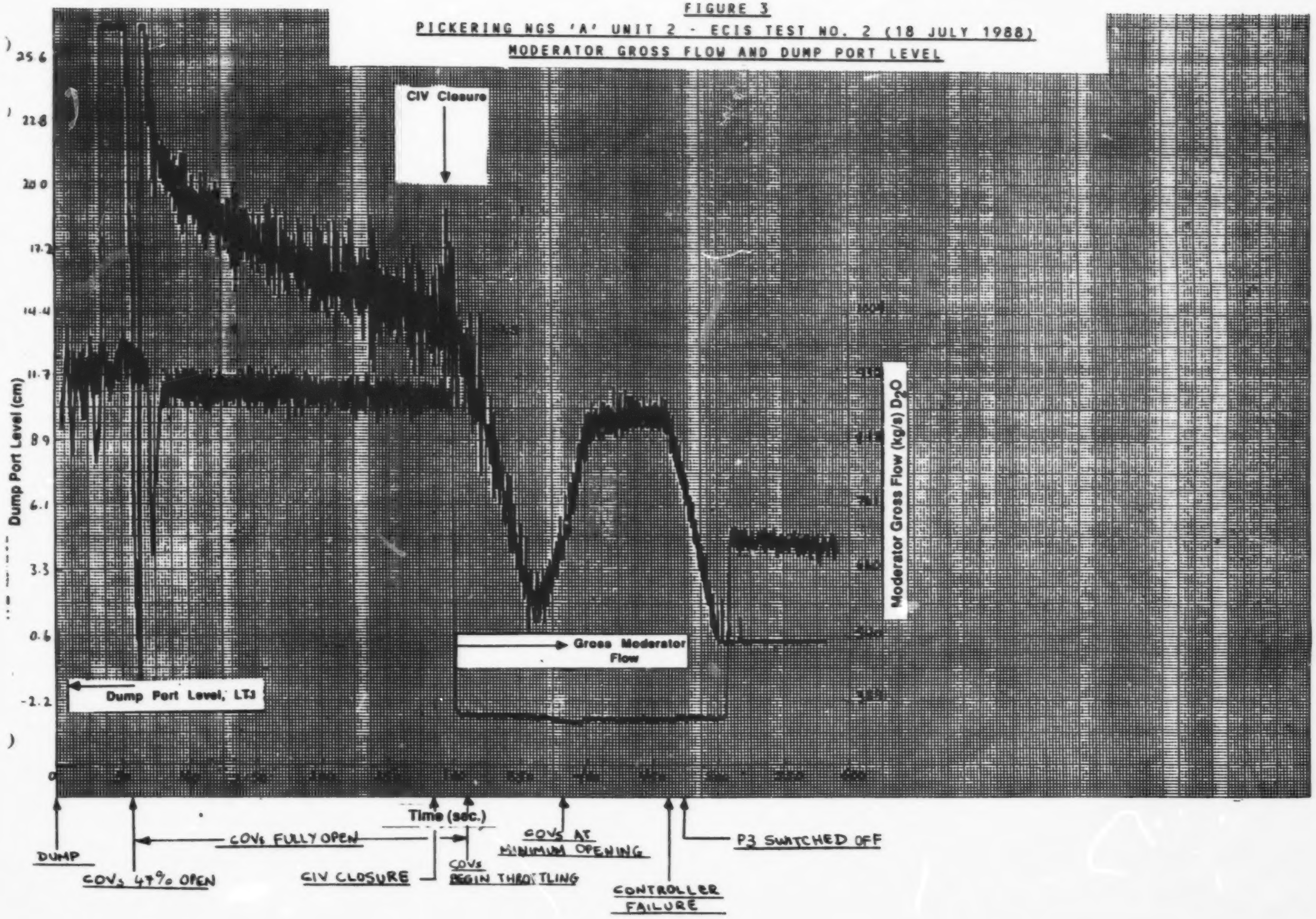


FIGURE 4

PICKERING NGS 'A' UNIT 2 - ECIS TEST NO. 2 (18 JULY 1988)

LIC1 OUTPUT, AND PUMPSET P3 SUCTION PRESSURE AND MOTOR CURRENT

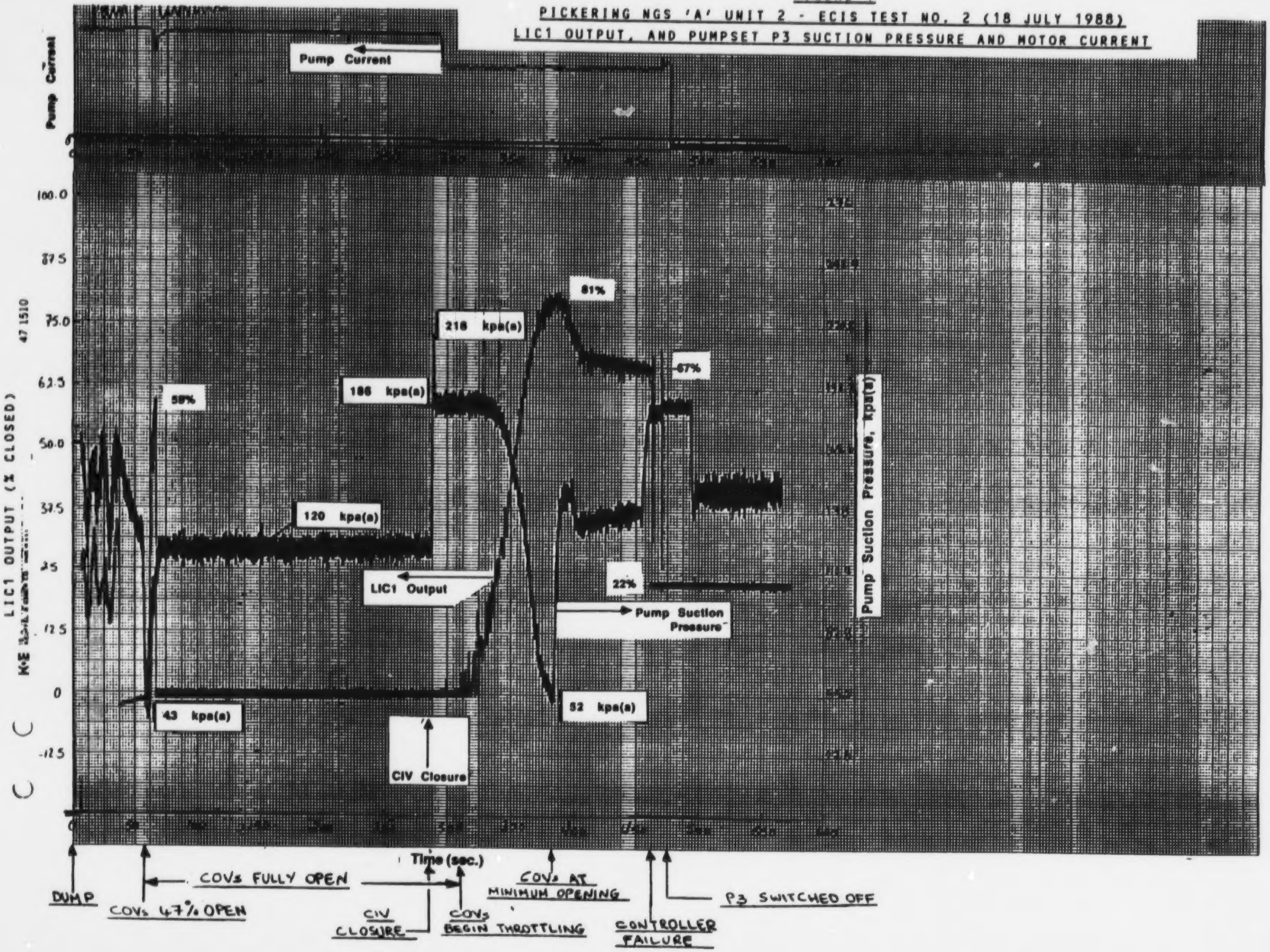


FIGURE 5

PICKERING NGS 'A' UNIT 2 - ECIS TEST NO. 3 (19 JULY 1988)

DUMP PORT LEVEL AND PUMPSET P3 SUCTION PRESSURE

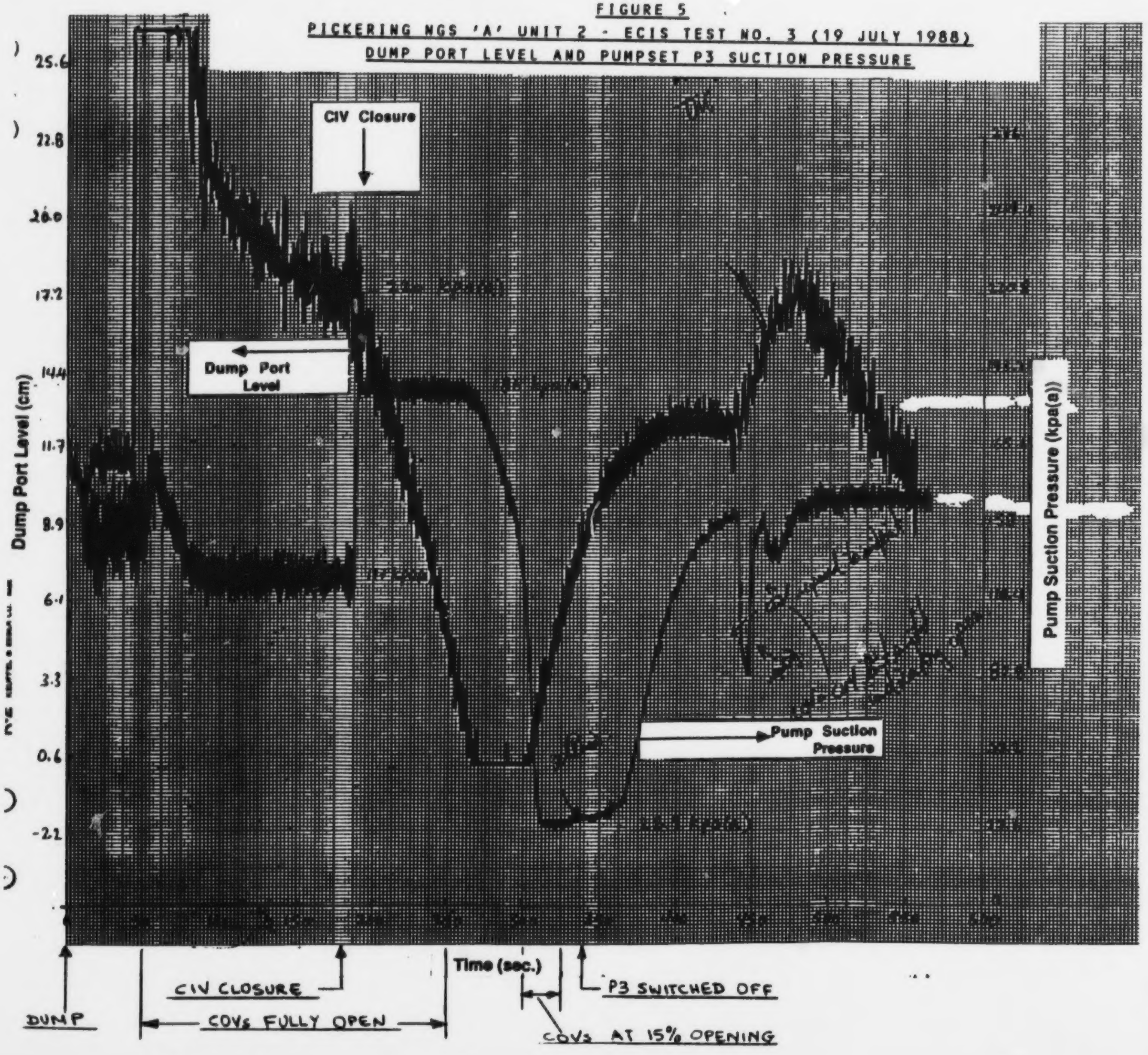


FIGURE 6

PICKERING NGS 'A' UNIT 2 - ECIS TEST NO. 3 (19 JULY 1988)

PUMPSET P3 MOTOR CURRENT